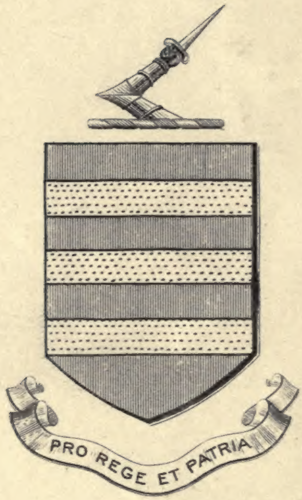
PRO REGE ET PATRIA

THE

# DEFORMITIES

OF

# THE HUMAN FOOT.

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# THE DEFORMITIES

OF

# THE HUMAN FOOT:

## *WITH THEIR TREATMENT.*


BY

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NEW YORK:
WILLIAM WOOD & COMPANY.
1895.

# PREFACE.

DURING the thirteen years I have had charge of the Orthopædic Department at St. Bartholomew's Hospital I have given, each winter and summer session, a series of demonstrations on the various deformities that there more especially come under notice, and I have been frequently asked by my dressers and the senior students attending these demonstrations to publish in book-form the substance of my remarks. Press of work alone prevented me from complying with their request. In 1892, however, my then senior dresser or clinical assistant, Mr. Kent Hughes, kindly offered to help me if I would bring out such a book, and undertook the entire labour of looking up references, and of collecting facts and verifying results of treatment, by working through the ten yearly volumes of bound orthopædic letters. He also undertook to superintend the taking of photographs from patients in the department, and from casts and specimens in the museum.

Conjointly, therefore, with Mr. Kent Hughes I started to write a book on Orthopædic Surgery, but some six months after it had been actively begun, Mr. Kent Hughes found that he would have to leave for his home in Australia a year or so earlier than he had at first intended. As I felt that without his aid it would be long before I could hope to finish the task on the lines laid down, we determined to confine our attention to Deformities of the Foot, the section in which we had made most progress. Hence the appearance of the present volume.

Although the work is essentially a record of our present and past experience in the Orthopædic Department, in which some 700 to 800 patients are annually treated, we have at the same time freely availed ourselves of the labours of other writers, and have endeavoured to make our account of the deformities of the foot more complete by discussing their views on causation, pathology, and treatment as well as our own. Further, it has been our aim to treat the subject rather from the standpoint of the general surgeon than merely from that of the orthopædic specialist.

We would more particularly acknowledge the help we have received from the works of Messrs. Hancock, Humphry, Ellis, Little, Adams, Reeves, Parker, Anderson, Hoffa, Rédard, Bradford and Lovett, and from the pamphlets and articles of various writers too numerous to mention, but duly referred to in the text.

To Mr. Berry our thanks are due for several specimens, notably one of extreme flat-foot; and to Mr. Codrington for many admirable dissections.

Most of the photographs were taken by Mr. Godard, but for many we are indebted to the kindness of Mr. Clindening and Mr. Griffiths. Some of the illustrations were copied by the kind permission of Mr. Ellis from his work on 'The Human Foot'; others from the works of Adams, Parker, Hoffa and Rédard.

Messrs. Arnold and Son, of West Smithfield, have greatly assisted us by courteously placing at our disposal drawings of many instruments contained in their catalogue.

W. J. WALSHAM.

77, Harley Street, W.,
*May* 1, 1895.

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# THE

# DEFORMITIES OF THE HUMAN FOOT.

## CHAPTER I.

### SOME ACCOUNT OF THE ANATOMY AND MECHANISM OF THE NORMAL FOOT.

Before discussing the abnormal conditions of the human foot, we will first briefly consider some points in its normal anatomy and mechanism. By referring to Figures 1 to 7 the reader will be able to refresh his memory as to the more elementary and obvious anatomical facts.

The skeleton of the foot is usually described as consisting of two longitudinal arches (an inner and an outer) and of a transverse arch.

The components of the two longitudinal arches have been differently given by various authors. The majority are in favour of the following arrangement: (*a*) *Outer arch*—os calcis, cuboid and two outer metatarsal bones. (*b*) *Inner arch*—astragalus, scaphoid, three cuneiform and three inner metatarsal bones. Hancock,* following Bishop, placed the os calcis in both arches, and seeing how intimately the os calcis and the astragalus are connected, this is by far the best arrangement. But the division into an inner and an outer longitudinal arch is somewhat artificial, and not strikingly apparent. A better idea of the mechanism of the foot will be gained by considering it in its entirety. For there is no sharp distinction between the functions of an inner

* Hancock, 'On the Operative Surgery of the Foot and Ankle-joint.' J. and A. Churchill, London, 1873.

and those of an outer arch, since, as will be shown hereafter, though the greater part of the weight of the body is transmitted through the scaphoid, and thus through the so-called inner arch, part of it is also transmitted through the inner portion of the cuboid —that is, through the outer arch. This will be more clearly seen when we consider the arrangement of the cancelli in the several bones as revealing the part that each bone takes in the exercise of the functions of the foot. Further, as Ellis* points


FIG. 1.—INNER VIEW OF THE TENDONS OF THE FOOT. (From a photograph of a dissection by Mr. Codrington, some time senior dresser in the Orthopædic Department.)

1. Extensor proprius hallucis ; 2. Tibialis anticus ; 3. Tibialis posticus ; 4. Flexor longus digitorum ; 5. Flexor longus hallucis ; 6. Tendo Achillis ; 7. Part of the tendon of abductor hallucis. The sole is slightly inverted, so as to bring the tendons on the plantar aspect into view.

out, the two feet should be regarded as complementary and as counterparts the one of the other. Viewed in this way, there is a distinct advantage in ignoring the artificial division into two longitudinal arches. Sufficient distinction and more clearness is obtained, by simply referring to the inner and outer sides of the foot, rather than to the inner and outer arches. The difference of opinion that exists as to the component parts of the longi-

* Ellis, 'The Human Foot.' J. and A. Churchill, London, 1889.

tudinal arches is in itself an evidence of the unsatisfactory nature of the division.

The transverse arch is usually described as formed by the cuboid and three cuneiform bones, the arch having its concavity directed downwards and inwards. The foot, however, is not only arched transversely at this situation, but is similarly arched from the fore-part of the os calcis and astragalus to the heads of the metatarsal bones; so that the two feet together, as Ellis graphically puts it, enclose 'a dome-shaped space' strongly marked in

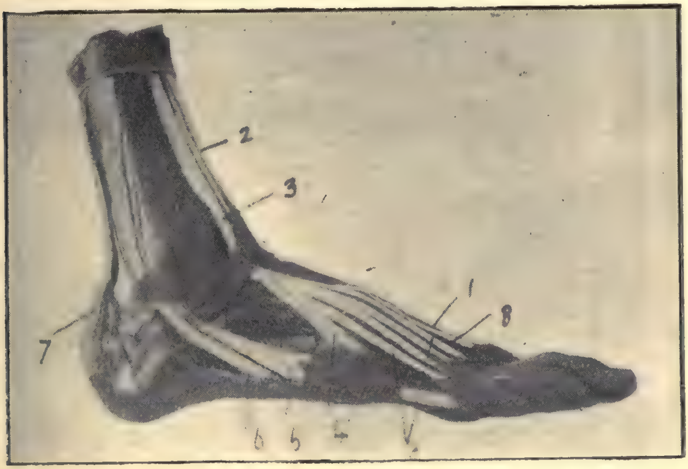



FIG. 2.—OUTER VIEW OF THE TENDONS OF THE FOOT. (From a photograph of a dissection by Mr. Codrington.)

1. Extensor proprius hallucis; 2. Tibialis anticus; 3. Extensor longus digitorum; 4. Peroneus tertius; 5. Peroneus brevis; 6. Peroneus longus; 7. Tendo Achillis; 8. Extensor brevis hallucis.

the skeleton, though more perfectly formed in the flesh-covered foot (see Fig. 8).

If we state, then, that the arching of each foot is in the form of a semi-dome, we express the fact that the foot is arched longitudinally and transversely, and also that the middle portion of its outer edge is on a lower level than the corresponding portion of its inner. The highest point of the semi-dome corresponds to the transverse tarsal joint. Posteriorly to this joint the curve descends rather rapidly with an inward inclination to the

internal inferior tubercle of the os calcis; anteriorly it descends more gradually with the same amount of inward inclination to the head of the first metatarsal bone so as to bring the inner edge of the first metatarsal bone into a line with the inner border of the internal inferior tubercle of the os calcis. This line, continued forwards, should lie along the inner edge of the great toe for its whole length. The inner edge of the foot, therefore, which corresponds to the surface of the median section of the dome-shaped space enclosed by the two feet, is practically in a straight


Fig. 3.—Inner and Under View of the Ligaments of the Foot. (From a photograph of a dissection by Mr. Codrington.)

1. Anterior tibio-tarsal; 2. Superior astragalo-scaphoid; 3. Scapho-cuneiform; 4. Deltoid; 5. Long calcaneo-cuboid (prolongation cut off); 6. Short calcaneo-cuboid; 7. Posterior calcaneo-astragaloid; 8. Posterior tibio-tarsal; 9. Inferior calcaneo-scaphoid, internal portion; 9*a*. Inferior calcaneo-scaphoid, plantar portion; 10. Internal cuneo-metatarsal.

line (Fig. 8). The fore-part of the outer edge of the foot, on the other hand, describes a curve with the convexity outwards, and acts the part of a lateral stay to the inner portion (Figs. 5, 9, and 23). That it does so is further borne out by the structure of the bones themselves, as will be shown hereafter (Fig. 20). The inner surface of the foot between the inner malleolar facet and the head of the first metatarsal bone is slightly curved with a convexity upwards and outwards, so that when the two feet are

placed parallel to each other an elliptical space is left between them. The outer surface from the outer edge of the external inferior tubercle of the os calcis to the base of the fifth metatarsal bone is sharply curved with its convexity upwards and inwards. The curve in the case of the inner surface is seen best in the foot with the soft parts intact; that of the outer surface in the skeleton only. These curves have reference to the manner in which the weight of the body is transmitted to the

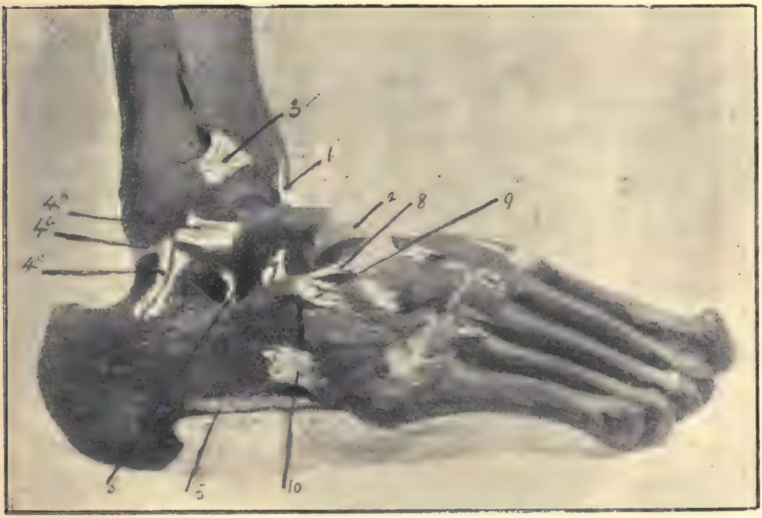


FIG. 4.—OUTER VIEW OF THE LIGAMENTS OF THE FOOT. (From a photograph of a dissection by Mr. Codrington.)

1. Anterior tibio-tarsal; 2. Superior astragalo-scaphoid; 3. Inferior tibio-fibular; 4*a*, 4*b*, 4*c*, Anterior, Posterior and Middle fasciculus of External lateral ligament; 5. Long calcaneo-cuboid ligament; 6 and 7. External calcaneo-astragaloid; 8. Superior calcaneo-scaphoid; 9. Internal calcaneo-cuboid; 10. Dorsal or superior calcaneo-cuboid.

foot, namely, in a direction downwards and inwards (Fig. 23). The inner part of the foot, which is curved upwards and outwards, receives all that part of the weight of the body which is not transmitted backwards to the posterior part of the os calcis, and it is strengthened by the supporting action of the posterior part of the outer edge, which is curved in an opposite direction upwards and inwards, and is situated at a lower level. 'The meta-

tarsal bones all slant a little inwards as well as downwards in the most favourable position to receive the weight of the body, which descends upon them with a slight obliquity, inwards, downwards and forwards' (Humphry).

By dismissing the artificial division into transverse and longitudinal arches, there is less temptation to strive to adapt the mechanism of the instep to that of an ordinary arch. It is, in

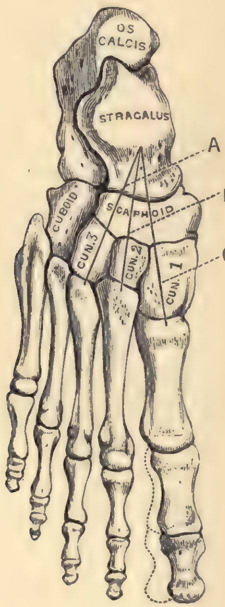



FIG. 5.—SKELETON OF THE FOOT (UPPER VIEW). (After Holden.)
*a*, *b*, *c*, are straight lines drawn to a point on the neck of the astragalus from the mid points of the three inner tarso-metatarsal articulations. The dotted line shows the plane of movement of the great toe.

fact, in no way comparable. There is no keystone. The weight from above is received wholly upon the posterior part of the foot, and that part of it which is transmitted forwards acts in the antero-posterior axis of the bones; whereas in an arch the weight is received from above along its whole span. Moreover, in the place of a rigid, passively resisting structure, we have an elastic living mechanism, actively adapting itself to every change

of position and function. Golding Bird also shows the weak points in the simile; he says (Guy's Hospital Reports, 1883): 'There are no piers on which the extremities of the arch can rest, nor by which they can be prevented from separating from each other. The (so-called) arch of the foot is kept in its position by the tying together of its two extremities by means of two distinct sets of bands, one of which is purely passive in its operation (the ligaments), and the other more or less active (the muscles).'

We may next briefly consider the part that each bone takes in the mechanism of the foot.

FIG. 6.—SKELETON OF THE FOOT (INNER VIEW). (From a photograph of a recently dissected foot.)

The position of the bones of the great toe and of the head of the astragalus is well seen. The phalanges of the great toe are generally represented as flat on the surface, which is not their position when the foot is not in action, excepting in persons suffering from 'flat-foot.' The head of the astragalus does not project inwards in a normal foot, as generally depicted in the text books.

**The Malleoli** are obliquely placed, the external being below and posterior to the internal, so that a line joining the two articular surfaces will lie in a plane directed forwards and outwards. The articular facet of the external malleolus is much smaller than the facet on the astragalus upon which it plays, allowing therefore a considerable amount of movement of the two bones upon each other, and much more than that which occurs between the internal malleolus and its articular surface on the astragalus.

**The Astragalus.**—This bone is frequently described as the key-

stone of the arch of the foot. Referring to our remarks on the subject of attempting to apply the mechanism of an arch to the foot, we would further point out that the astragalus is not at the centre of the so-called arch; it has not the shape of a keystone; it is movable, not fixed; and its under-surface is not free, but so closely connected with the so-called posterior pillar of the arch (the os calcis) as to act in a normal foot as if it were part of it. Its upper articulating surface has been called the summit of the arch of the foot. This is truly carrying the analogy even beyond a far-fetched simile, for, as Hancock* says, The upper articular surface of the astragalus has as much relation to the summit of the arch of the foot as the roofs of the houses to the summit

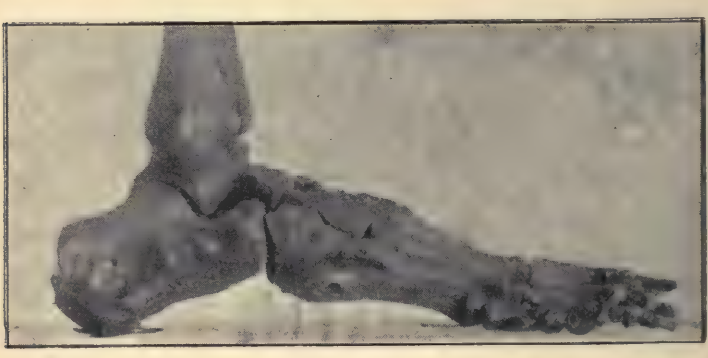


FIG. 7.—SKELETON OF THE FOOT (OUTER VIEW). (From a photograph of a recently dissected foot.)

It will be observed that the head of the astragalus projects on the outer side.

This and the preceding figure, No. 6, were obtained from a foot the bones of which were secured in their normal position before removal of the ligaments.

of the arch in old London Bridge. Not as much, in fact, for the summit of an arch is centrally placed, and the forepart of even the under surface of the astragalus is behind the centre of the arch of the foot.

We will again refer to the projecting posterior piece of the astragalus, by means of which it is firmly gripped by the os calcis, thus preventing dislocation of the bone forwards when the foot has to bear the pressure of a sudden shock during full plantar flexion.

* *Loc. cit.*

The general inclination of the neck and head of the astragalus is markedly inwards, but the upper and outer portion of the neck has a slight outward twist; this outward twist, however, is not strongly marked in a normal bone, but in an astragalus from a case of severe flat-foot it is much exaggerated.

The *trochlea* or *superior articular surface* of the astragalus is of a curious shape. It is sharply convex from before backwards, but from side to side exhibits a shallow concavity. It is narrowest


FIG. 8 'represents impressions taken with printer's ink, and reduced, from the sole of a boy æt. 11½, in duplicate. The awkward look of a single sole print is not apparent when the two are seen together, the curves round the toes running into each other gracefully. The line (*a*) known as Meyer's line, is seen to run through the centre of the heel and along the middle line of the great toe. A line (*b*) from the inner side of the heel to the inner side of the great toe will be found to pass clear of the joint at the root of the latter. The form of the area covered as by a dome or bell shaped covering, when the two ankles are joined, is also evident.' (After T. S. Ellis.)

posteriorly, the posterior edge being often only half the width of the measurement at the widest part, which latter varies in its position, being sometimes just anterior to the centre, at other times about half-way between the centre and the anterior edge, the width of the trochlear surface gradually diminishing from the widest portion to the anterior edge. The inner edge is placed almost directly antero-posteriorly, the anterior extremity being just a little internal to the posterior. The outer edge, on the

contrary, describes a bold curve, running *forwards and outwards* from the posterior extremity to a point somewhat beyond the centre of the trochlea (varying as above noted, *re* widest measurement); it then curves *forwards and inwards*, the last part of the curve being so sharp as to present a hooked ending.

Some astragali, about one in five, do not exhibit any sharp curving forwards and inwards of the anterior part of the outer edge, and consequently the measurement of the anterior edge is almost as great as that at the widest part. The difference between the measurement of the widest part of the trochlea and

FIG. 9 'is from a photograph of the same feet as in Fig. 8. Each of the inner lines indicates the tendons of the tibialis anticus muscle. The outer line (corresponding to Meyer's line in the sole) represents the leading line on the back of the foot, following the crest of the ridge. The buttress-like appearance of the part of the foot corresponding to the two outer toes is clearly shown.' (After T. S. Ellis.)

that of the anterior edge was found to be as follows in twelve astragali taken at random:*

| Measurement at widest part. | Measurement at anterior edge. |
| --- | --- |
| 1·25 in. | 1·125 in. |
| 1·125 in. | 1·0625 in. |
| 1·1875 in. | 1·125 in. |
| 1·0625 in. | ·875 in. |
| 1·0625 in. | ·875 in. |
| 1·1875 in. | 1·00 in. |

* Many astragali were rejected owing to imperfections in the trochlear surface.

| Measurement at widest part. | Measurement at anterior edge. |
|---|---|
| 1·0625 in. | ·875 in. |
| 1·125 in. | ·75 in. |
| 1·0625 in. | ·80125 in. |
| 1·00 in. | ·80125 in. |

In *two* the measurement was almost equal. Thus there was an average difference of ·1835, or, including the two astragali in which the measurement was almost equal, an average difference of ·153.

*The inner edge* is curved with its convexity upwards and slightly outwards, and represents the segment of a circle lying almost vertically in an antero-posterior plane. *The outer edge* is more sharply curved, with its convexity outwards and slightly

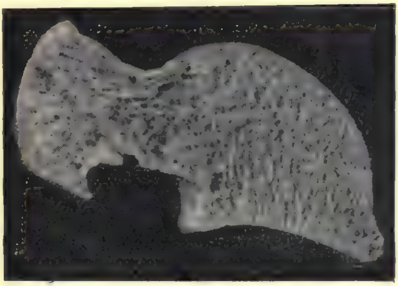


FIG. 10.—LONGITUDINAL SECTION OF THE ASTRAGALUS, SHOWING THE ARRANGEMENT OF THE CANCELLI.

The groove running obliquely across the neck is the remnant of a passage for a catgut string. (From a photograph of a section made by W. Kent Hughes.)

upwards. It represents the segment of a larger circle lying in an oblique plane passing from above downwards and inwards.

Looking at the bone in the position which it occupies in a foot placed horizontally, the anterior and posterior portions of the trochlear surface will be seen to lie in two planes, directed upwards, backwards, and outwards, and upwards, forwards, and outwards respectively, the lateral inclination of the two planes to each other joining at an angle of about 120°.

The *structure* of the astragalus, as shown by a longitudinal section, is very firm, being composed of closely-set striæ, with only a few cancellated spaces above the interosseous groove

(Fig. 10). The striæ in the body are directed from the trochlea towards the posterior articular facet for the os calcis. The middle striæ run downwards, the posterior downwards and forwards, the anterior downwards and backwards. In the neck the striæ pass directly forwards towards the head of the bone for nearly its whole depth, there being a few directed downwards, and slightly forwards, to the facet articulating with the anterior superior facet of the calcis. The striæ in the neck of the astragalus are the strongest in the foot. Some striæ may be seen passing horizontally across the body of the bone from the posterior part of the trochlea to the neck; these serve to transmit the weight of the body forwards (Fig. 10) when the foot is plantar-flexed. They are not, however, very well marked in this section, which has been chosen rather for the general distinctness of detail.

The weight of the body is transmitted to the astragalus from the tibia downwards and inwards, but the direction in which it is transmitted from the astragalus varies with the position of the foot. The greater the plantar flexion of the foot, the larger the amount of force transmitted downwards and forwards through the neck and head; the greater the dorsal flexion, the larger the amount of force transmitted downwards and backwards to the calcis.

**The Os Calcis.**—The os calcis rests on the two inferior tubercles, which are obliquely placed, the inner surface of the calcis being deeper than the outer, and the external tubercle slightly anterior to the internal; the bone thus assumes an oblique position when resting on a flat surface. Its mesial axis runs forwards, and slightly upwards and outwards. This obliquity makes the bone better able to receive the weight which comes upon it in an oblique line from above, downwards and inwards (Humphry).

The large posterior facet which articulates with the body of the astragalus has its longest diameter directed obliquely forwards, downwards and outwards. It is convex both in its longest diameter and also transversely, except for its uppermost portion, which, as it inclines inwards towards the inner end of the interosseous groove, is slightly concave, forming with the sustentaculum tali a 'cup-like cavity, wherein rests the posterior portion of the astragalus' (Hancock). By this means the posterior projecting portion of the astragalus obtains a firm grip of the os

calcis, and resists the tendency of the bone to be displaced downwards and inwards in certain positions of the foot. 'For it must be remembered that the astragalus has no muscles to keep it in position, and that it relies therefore solely upon its osseous and ligamentous connections for support.' When the heel is raised, and the weight of the body is supported entirely by the anterior part of the foot, the astragalus is forced downwards, and would have a greater tendency to be displaced, were it not for the above-mentioned 'cup-like cavity.'

Examining the structure of the os calcis by means of a longitudinal section (Fig. 11), through the middle of its posterior

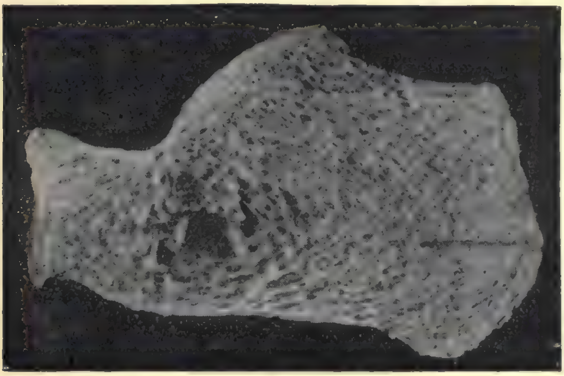


FIG. 11.—LONGITUDINAL SECTION THROUGH THE OS CALCIS, SHOWING THE ARRANGEMENT OF THE CANCELLI.

The striæ in places have a deceptive appearance of strength, especially anterior and posterior to the triangular interval—the apparently thick and strong striæ being merely the lateral surface of thin lamellæ which run in a different direction to the others—this is also partly the case with the cuboidal surface of the bone. (From a photograph of a section of the bone made by W. Kent Hughes.)

articular facet, we find that the floor of the interosseous groove is composed of a comparatively thick layer of compact bone, almost ivory-like in consistence. This layer is continued forwards to a short distance beyond the groove, narrowing as it passes anteriorly. Posteriorly it runs into the broad layer of dense bone beneath the postero-external articular surface, which reaches its maximum depth about the centre. Immediately beneath the interosseous groove is a triangular space formed by an interval

between the radiating striæ of the cancellous tissue; the compact bone forming the floor of the groove is the meeting-point of striæ radiating anteriorly and posteriorly, and of a few striæ which descend almost vertically to the inferior surface of the bone. The anterior striæ run to the upper half of the articular surface for the cuboid. These striæ are less numerous and are frailer in their dimensions than the striæ in the neck of the astragalus that run towards its anterior articular surface for the scaphoid (Fig. 10).

The striæ in the fore-part of the os calcis and astragalus may be taken to fairly represent the amount of work borne by each bone in transmitting the weight of the body to the cuboid and scaphoid respectively. It is difficult, however, and almost impossible, to say in what definite proportion. Numerically, there are only half as many striæ in a longitudinal section of the cuboidal surface of the os calcis as there are in the head of the astragalus. But, besides the numerical deficiency and the more delicate formation of the striæ in the fore-part of the os calcis, there is only about half the extent of bone in this area that there is in the striated portion of the head of the astragalus; therefore it would appear that only a small proportion of the weight of the body is transmitted through the os calcis to the cuboid as compared with that transmitted through the neck of the astragalus to the scaphoid.

'It is in like manner, in accordance with the oblique direction in which the weight is received, that the inner side of the foot is stronger than the outer, that the metatarsal bone of the hallux is twice as strong as any of the others, and that the arch of the instep is higher on the inner than on the outer side' (Humphry).

The distribution of the striæ of the rest of the body of the bone should also be noted. Beneath the posterior articular surface the striæ, in its lower three-fourths, run in a gentle curve downwards and backwards with the concavity of the curve downwards and forwards; in its upper fourth they run backwards and downwards in a curve having a concavity upwards and slightly backwards.

Again, from the posterior three-fourths of the inferior surface of the bone, other striæ run at right angles to the former, backwards

and upwards in a curve with its concavity forwards, and near the posterior extremity they are very closely aggregated, and form almost compact osseous substance. Running somewhat in the same direction, some striæ start from the lower part of the cuboidal surface backwards and downwards to the triangular interval, where they change their direction to one backwards and upwards, the concavity of the curve looking upwards and in its last portion distinctly forwards.

The double arch formed by the striæ passing from the posterior articular surface supplies a very strong mechanical arrangement for supporting the pressure of the body transmitted downwards and backwards to the posterior articular surface when standing. The striæ curving upwards from the inferior surface of the bone

FIG. 12.—SECTIONS THROUGH THE SCAPHOID IN THE DIRECTION OF THE STRAIGHT LINES *a*, *b*, *c*, IN FIG. 5. (From a photograph of sections by W. Kent Hughes.)

with a concavity forwards and upwards, have reference to the direction in which the pull of the tendo Achillis acts. The striæ forming a curve with the concavity upwards resist the downward pressure of the weight of the body. Beneath the anterior facet for the astragalus a few striæ will be found, passing downwards from the under surface of the facet as a base to a strong layer of compact bone lining the fore-part of the inner surface of the os calcis.

In running the heel is off the ground, and the whole weight of the body is thrown upon the heads of the metatarsal bones, principally the first, that part which is transmitted to the posterior articular surface of the os calcis towards the heel being thrown

forwards by the pull of the tendo Achillis, partly along the cuboid, and partly along the neck of the astragalus, the os calcis and astragalus thus acting like the two parts of a consolidated whole.

**The Scaphoid** has been described by Hancock as the keystone of the arch. It is certainly more centrally placed, and is more of the shape of a keystone than is the astragalus, but we would again refer to the objections that we have elsewhere made to attempts to apply the mechanism of an arch to the foot.

The scaphoid is the medium through which force is transmitted to and from the astragalus and cuneiform bones; it is also a centre of movement, and gives attachment to strong muscles and ligaments. It is a very important bone, but it does not perform any of the functions of a keystone—it has none to perform. It does not receive any weight from above, and does not hold up the arch of the foot.

FIG. 13.—SECTION THROUGH ANOTHER SCAPHOID IN THE DIRECTION OF LINE *b* IN FIG. 5.

The anterior facet is divided into three portions for articulation with the cuneiform bones. If straight lines be drawn backwards from the mid-point of the posterior articular surface of the three inner metatarsal bones, they will be found to meet at a point at the middle of the neck of the astragalus, just in front of the trochlea (Fig. 5). If sections be now made through the scaphoid in the directions in which these lines cross it, they will be found to correspond with the direction of the striæ in the bone; to correspond, that is to say, with the direction in which the lines of force are transmitted through the scaphoid to the cuneiform bones. The bone in structure is very dense, and marked with striæ running in the directions noted above, except-

ing in that portion internal to the articular surface, namely, the tubercle, and in the plantar edge of the bone along its whole length below the articular surface. The structure here is much lighter and cancellous, and does not show any striation, being

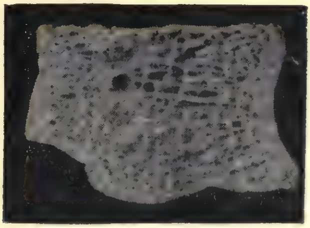


FIG. 14.—SECTION THROUGH THE CUBOID INSIDE A LINE DRAWN FROM THE OUTER EDGE OF THE OS CALCIS DIRECTLY FORWARDS, SHOWING STRIÆ RUNNING ANTERO-POSTERIORLY — FEW IN NUMBER, AND WITH COMPARATIVELY WIDE SPACES BETWEEN THEM. (From a photograph of a section made by W. Kent Hughes.)

simply used for the purpose of attachment of muscles and ligaments.

**The Cuboid.**—The structure of the cuboid gives further striking evidence of the fact that the outer part of the foot is not much concerned in transmitting weight forwards. If a longitudinal

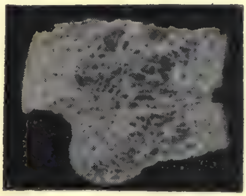
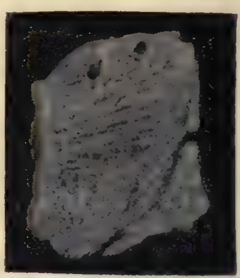


FIG. 15.—SECTION THROUGH THE CUBOID OUTSIDE A LINE DRAWN FROM THE OUTER EDGE OF THE OS CALCIS DIRECTLY FORWARDS, SHOWING ABSENCE OF STRIATION AND IRREGULAR CANCELLATED SPACES. (From a photograph of a section by W. Kent Hughes.)

section be made through the bone in a line with the outer surface of the os calcis, it will be found to divide the bone into two parts, an outer portion consisting of loose cancellous tissue, non-striated, and an inner portion definitely striated. The striæ, which are, however, few in number and widely separated, pass

from before backwards (Figs. 14 and 15). Professor Humphry says that the outer part of the foot acts as a lateral stay to the inner, but this statement, it would seem, should be confined to the fore-part of the foot, as no evidence of the cuboid acting in this manner can be found by means of sections. Further, Professor Macalister writes: 'The inner side of the foot is the more actively



FIGS. 16 AND 17.—SECTIONS OF INTERNAL CUNEIFORM BONE. (From photographs of sections made by W. Kent Hughes.)

functional in weight-bearing; the outer is essentially retrogressive, and shows many signs of degeneration of its separate elements.'*

**The Internal Cuneiform Bone** as seen in a vertical antero-posterior section (Figs. 16 and 17) is divisible into three portions.

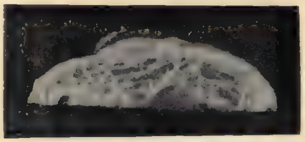


FIG. 18.—OBLIQUE SECTION OF INTERNAL CUNEIFORM BONE, SHOWING 'PULL' OF TIBIALIS ANTICUS. (From a photograph of a section made by W. Kent Hughes.)

The median portion is made up of striæ running antero-posteriorly from the concave articular surface for the scaphoid to the middle portion of the articular surface for the first metatarsal bone. The lower portion of the bone is made up of somewhat loose cancel-

* Macalister, 'A Text Book of Human Anatomy,' 1889, p. 198.

lous tissue. The upper portion is also honeycombed, but denser than the lower, though there is no evidence of definite striation.

Sawing the bone through obliquely from the antero-inferior angle to the postero-superior, we divide it in the line of the 'pull' of the tibialis anticus tendon, the direction of which

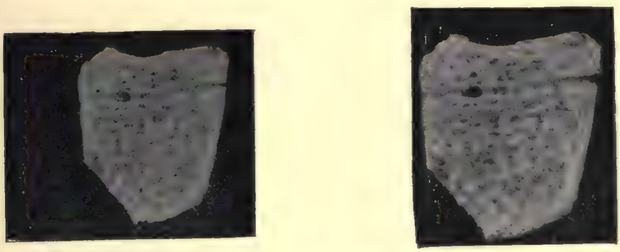


FIG. 19.—SECTIONS OF EXTERNAL CUNEIFORM BONE. (From photograph of sections by W. Kent Hughes.)

(Fig. 18) is marked by striæ running from the insertion of the tendon upwards and outwards.

**The Middle and External Cuneiform Bones** show a similar structure upon being sawn antero-posteriorly in a vertical direction; the upper three-fourths of each bone is marked by definite

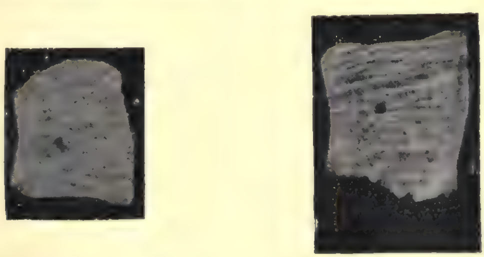


FIG. 20.—SECTIONS OF MIDDLE CUNEIFORM BONE. (From photograph of sections by W. Kent Hughes.)

striæ running antero-posteriorly; the lower fourth is composed of loose cancellous tissue (Figs. 19 and 20).

**The Base of the Fifth Metatarsal Bone.**—Lastly, as anatomical evidence that the outer part of the front of the foot acts as a lateral stay to the inner, we refer to Figs. 21 and 22, which

illustrate a section of the base of the fifth metatarsal bone, showing striæ running from the outer side inwards and slightly upwards.

## The Mechanism of the Foot.

1. **Movements of the Foot at the Ankle-joint.**—The movements here are: (*a*) Dorsal flexion with very slight eversion of the sole

FIG. 21.—SECTION OF THE BASE OF THE FIFTH METATARSAL BONE, SHOWING STRIÆ RUNNING FROM WITHOUT, INWARDS AND SLIGHTLY UPWARDS.

and abduction; (*b*) Plantar flexion with very slight inversion of the sole and slight adduction. Most authors state that flexion and extension are the only movements possible at the ankle-joint, but a careful consideration of the conformation of the trochlea will show that the movements must necessarily be compound.

FIG. 22.—SECTION OF THE BASE OF THE FIFTH METATARSAL BONE. This section was taken from a bone in which the striæ were very large. (From photographs of sections by W. Kent Hughes.)

When the foot is at a right angle with the leg, the articular surface of the tibia rests upon the central part of the trochlear surface of the astragalus at the place where its two oblique planes meet. If the foot be plantar-flexed, the astragalus rotates downwards and inwards upon a transverse axis, carrying the

scaphoid with it; slight adduction and inversion of the foot is produced at the same time and the heel is carried upwards and slightly outwards.

If the foot be now fully dorsal-flexed, the head of the astragalus passes upwards and outwards, the foot becomes slightly everted and abducted as well as dorsal-flexed, and the heel is carried inwards and downwards. But the anterior part of the outer edge of the trochlea is not so sharply curved inwards as the posterior part; therefore the eversion accompanying dorsal flexion is less marked than the inversion accompanying plantar flexion.

In a foot with a good instep this eversion will not proceed further than to restore the foot to the middle line, overcoming the inversion that occurs with plantar flexion; but in a foot with a low arch (*i.e.*, a foot in which a mechanical tendency to flat-foot exists) the eversion and abduction may go beyond this point, and the foot be everted and abducted as well as dorsal-flexed.

'Why should the ankle be so constructed that it is projected outwards as the foot comes to full extension in moving forwards? There are two distinct advantages. One is that the ankle of the moving foot is thrown out of the way of the other as the former is brought past the latter. Thus brushing of the uplifted foot against the ankle on the opposite side is avoided. The other advantage is that the excessive extension of the foot, which conveying it directly over the tip of the great toe would involve, is unnecessary, because the foot is, in fact, carried over the outer or shorter toes' (Ellis).

2. **The Movements of the Foot at the Sub-astragaloid Joint,** *i.e.*, the joint formed by the astragalus above, and by the os calcis, scaphoid and calcaneo-scaphoid ligament below. The movements here are: (*a*) Adduction and inversion; (*b*) Abduction and eversion.

Adduction and inversion, and abduction and eversion of the foot take place chiefly at this joint, the first set of movements being performed with more freedom. Adduction of the foot upon the astragalus is limited by the impaction of the posteriorly projecting part of the astragalus in front of the groove for the flexor longus hallucis against the sustentaculum tali and the inner

end of the interosseous ligament. Abduction of the foot upon the astragalus is limited by the internal part of the inferior calcaneo-scaphoid ligament, and by the impaction of the portion of bone anterior to the external malleolar facet against the outer end of the interosseous ligament and the adjoining surface of the os calcis.

The middle fasciculus of the deltoid ligament also assists in limiting abduction, and the interosseous calcaneo-astragaloid ligament limits both movements, especially abduction. In abduction of the foot upon the astragalus, the astragalus is thrown slightly forwards and inwards. In adduction it is thrown slightly backwards and outwards.

3. **The Movements of the Foot at the Medio-tarsal or Transverse Tarsal Joint**, *i.e.*, the joint formed by the os calcis and astragalus posteriorly, and the cuboid and scaphoid anteriorly. The movements here are chiefly abduction and adduction, with some eversion and inversion, flexion and extension.

'Between the first and second row of tarsal bones,' says Professor Humphry, 'flexion and extension of the second upon the first occurs in a plane drawn from within outwards, backwards and downwards through the calcis and astragalus. Direction of movement corresponds with the long diameter of the convex facet of the astragalus.' The shape of the calcaneo-cuboid articulation only favours movements of the cuboid on the calcis downwards and inwards, and therefore opposes abduction.

While, then, we see that adduction of the foot can be freely performed up to a certain point without obstruction from ligaments or osseous connections, abduction is in every way opposed; the surfaces of the bones in the calcaneo-astragaloid, astragalo-scaphoid, and calcaneo-cuboid articulations favour adduction, and are antagonistic to abduction. This deficiency of movement towards abduction can be made up for in part by rotation of the leg outwards, a point which will be further discussed in the chapter on Flat-foot.

**Standing.**—During the act of standing in the natural position the weight of the body is transmitted through the upper part of the tibia in a direction downwards and outwards, but, owing to a twist in the shaft of the tibia at the junction of its middle and lower third, it is transmitted onwards to the astragalus in a

direction downwards and inwards (Fig. 23). In consequence of this arrangement, the weight of the body is continually striving to cause the foot to assume a 'valgus' position. Viewed in the skeleton the foot is seen to be in a condition of unstable equilibrium, and on that account some have asserted that the mechanism of the foot is at fault. But, as Mr. Ellis so truly says, 'Of course, the tendency of the tarsal arch is to give way. How otherwise could there be sufficient elasticity? Although the yield-

FIG. 23.—VERTICAL TRANSVERSE SECTION THROUGH THE ANKLE.

**The interosseous ligament is seen filling up the groove in the astragalus and in the os calcis. The two leg bones, the tibia on the inner and the fibula on the outer sides, are also shown with the expanded lower ends cut through. The inclination inwards, showing an apparent disposition to give way, is very manifest. (After T. S. Ellis.)**

ing element exists, as already stated, it is a necessity. Unless the arch were made, like a piece of masonry, unyielding, it must yield according as it is braced *up* by the muscles, as in walking, or pressed *down* by the weight of the body, as in standing at ease or in falling suddenly on the feet. To say that this tendency "has to be constantly combated by the action of the strong leg muscles," ignores the fact that they do this not as a special exertion for that purpose; they do it *in* fulfilment of their proper

functions, in moving the foot on the leg and the leg on the foot. They and their action would be just as necessary if no such extra need existed. It is one of the beauties of the animal mechanism, frequently manifest, that more than one purpose is effected by a single action, just as more than one effect generally results from the exercise of function in the different organs of the body.'

From the astragalus the greater part of the weight is transmitted to the posterior portion of the os calcis, a small part to its anterior articular surface and so to the outer side of the foot, the rest along the neck and head of the astragalus to the scaphoid. To estimate roughly the amount transmitted in these several directions, place the fingers of one hand under the heel and those of the other under the heads of the metatarsal bones of a person standing on a firm level surface, the line of the fingers of the latter hand being at right angles to the line of the metatarsal bones, and endeavour with each hand separately to overcome the downward pressure of the weight of the body; it will then be strikingly evident what a very large proportion of the body-weight is transmitted to the heel. It will also be noted that the pressure at the outer part of the foot on the anterior hand is in a direction downwards and outwards, showing that the outer and front part of the foot is acting as a stay to the inner. The posterior part of the os calcis therefore has an enormous strain put upon it when the foot is at right angles to the leg in the standing position, and to meet this strain the bone is provided with the elaborate system of arched striæ before referred to (p. 13).

When the foot is fully plantar-flexed, the weight of the body is received upon the posterior part of the trochlea and transmitted in a direction forwards, downwards and further inwards than when standing naturally. When in full dorsal flexion, the weight is received upon the anterior part of the trochlea and transmitted backwards, downwards and slightly inwards. The foot, however, is not often called upon to support much pressure in the latter position.

When standing with the foot at a right angle to the leg, the straight line joining the centre of the two malleoli lies in a plane directed forwards and outwards; when the foot is fully plantar-

flexed, the external malleolus is placed further posterior as regards the internal, and the straight line joining the centre of the malleoli looks more outwards, a permanent condition met with in congenital varus and in equinus. When the foot is fully dorsal-flexed, the external malleolus takes up a position further anterior, being brought into the same tranverse plane with the internal, so that the straight line joining the centre of the malleoli now looks forwards. In a foot with a good arch the external malleolus is never brought further forward than the internal; but in some people with a low arch (*i.e.*, with a mechanical tendency to flat-foot) the external malleolus can be brought in front of the internal; whilst in a well-marked case of flat-foot it can be observed to be sometimes as much as a sixth of an inch in front of it.

Abduction and adduction of the foot, as we have already seen, take place chiefly at the subastragaloid joint. When we stand with the feet abducted the astragalus is carried slightly forwards and inwards, and therefore extra weight is thrown upon the fore-part of the os calcis and with a more marked inward inclination. Hence the sustentaculum tali is lowered and carried inwards whilst the external posterior tubercle is raised from the ground, the whole bone thus rotating on an antero-posterior axis. The tubercle of the scaphoid, following the astragalus, is also rotated downwards and inwards, while the scaphoid as a whole with the bones in front of it is displaced forwards and outwards, thus lengthening the inner side of the foot and consequently diminishing the height of the longitudinal arch. In the meantime, as pointed out by Lane,* the first row of tarsal bones as a result of the forward and outward displacement of the scaphoid rotate round a vertical axis passing through the calcaneo-cuboid joint and so shorten the inner edge of the foot. When we stand with the feet adducted the reverse of these movements takes place; and as a result the inner border of the foot is decreased in length, the arch increased in height and the outer border of the foot lengthened.

We have found on measuring the inner and outer borders of the living foot during abduction and adduction that the alteration is more marked in the inner edge in each instance, and that there

* 'Guy's Hospital Report,' 1878.

is no relative amount of increase or of diminution in proportion to the length of the foot, a small foot with lax ligaments undergoing greater change than a long foot with the bones tightly bound together. In two persons five feet seven inches in height, with length of foot ten inches, the difference in length of the inner edge in strong adduction and strong abduction in the one instance was only one-eighth of an inch, in the other nearly three-eighths of an inch. In a person six feet high with a foot eleven and a half inches in length, the difference between the length of the inner edge in strong abduction and strong adduction was only a quarter of an inch. The change in the length of the inner edge is about double that of the outer, as in the first of the above instances, where the change in the length of the inner edge was a quarter of an inch, in the outer only one-eighth of an inch.

The measurements were taken from the middle point of the heel behind and the most anterior points of the inner and outer edge respectively. The anterior point of the inner edge was obtained by producing forwards the straight line joining the inner surface of the posterior edge of the os calcis and that of the head of the first metatarsal bone, and then drawing a line at right angles to it from the tip of the great toe. The length of the outer edge was obtained by producing the outer edge of the foot forwards and drawing a line at right angles to it from the tip of the little toe. The feet were first measured pointing directly forwards, and then when strongly abducted and strongly adducted. In strong adduction care must be taken that the sole is not inverted, or too great a change will be registered.

In abduction the weight of the body is borne chiefly by the connection of the bones with each other and by their ligaments, the muscles taking very little share in maintaining the bones in this position. Thus the tibialis posticus and the flexors are unduly stretched and so rendered tense, whilst the remaining long muscles of the leg and foot are slackened by the approximation of their points of attachment. In adduction, on the other hand, the foot is braced up by muscular contraction and pressure is thus taken off the ligaments. The tibialis anticus and tibialis posticus are especially concerned in holding the foot in this position of adduction; the former supports the internal cuneiform and base

of the first metatarsal bone; and the latter, whilst drawing the scaphoid upwards and inwards, forces the head of the astragalus upwards and outwards and so keeps the bone in position.

Thus we see that to stand with the feet adducted requires some muscular effort, whilst to stand with the feet abducted entails but little, and is hence the position which is apt to be assumed when standing continuously and when tired, a position which has therefore been well called by Annandale the 'attitude of rest.' Adduction is the position of strength; the muscles are actively contracting; the inner edge of the foot is shortened and the arch is well-braced up and therefore more capable of resisting the downward and inward pressure of the weight of the body. Abduction,

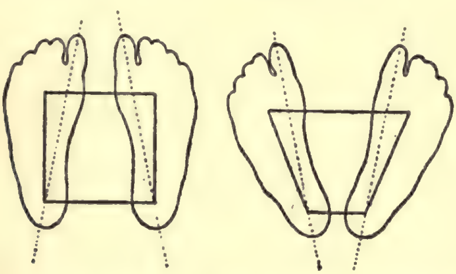


FIG. 24.—THE FOUR-SQUARE AND THE MILITARY POSITION IN STANDING. (After Ellis.)

on the contrary, is the weak position; no muscles are actively contracting, the inner edge of the foot is lengthened, and the arch is decreased in depth, and is hence less able to resist the downward and inward pressure of the weight of the body. The burden of resistance therefore falls chiefly on the passive tissues, the ligaments; and when these are subjected to continuous strain they gradually yield, allowing the joints to sink into whatever position, and the articular surfaces to assume whatever form, the weight of the body may determine (Ellis). The troubles that may arise from long continuance in the abducted position will be discussed under Flat-foot.

Ellis, who has forcibly described the evils of the military position of standing with the feet at an angle of forty-five degrees, that is, in a position of marked abduction, advocates for soldiers the

placing of the feet parallel or slightly adducted, 'the central points in the heel and in the tread being equally distant.' He maintains that this is the better position—(1) because it is four-square (see Fig. 24), and (2) because it is the strong position of the arch, the convexity being at its greatest and the muscles being in action.

**Walking.**—It is a matter of some dispute which part of the foot reaches the ground first in walking, or, rather, which part of the foot ought first to reach the ground; for it is evident that the very large majority of people wearing the ordinary modern boot put the heel to the ground first; and not only does the heel reach the ground before the toes, but the foot in ninety-nine cases out of a hundred is in a position of marked abduction. We have shown above* that adduction is the strong position of the foot, abduction the weak; it must therefore be as antagonistic to the mechanism of the foot to walk with the feet abducted as it is to stand with the foot in a similar position. Because the great majority of people walk with feet abducted, it would be just as reasonable to argue that therefore abduction must be the natural position of the foot in walking as to draw the conclusion that because most people in walking touch the ground with the heel first, that therefore that must be the natural method of progression.

In running all agree, anatomists and athletes alike, that the proper method of progression is from 'toe to toe,' the heels being off the ground all the time. Yet if we watch in the streets those who run, when hurrying to catch a train, etc., we see the very large majority put their heels to the ground before the toes, and those who have had experience in training athletes know that the first principle they have to instil into beginners is to make them run on their toes instead of their heels. Moreover, when an athlete is beginning to tire in a long race, his first inclination is to 'drop on to his heels' until he is taught to try to keep his stride long, which can only be done by springing from 'toe to toe.' In the case of running, then, we see that people almost universally have to be taught how to best bring into play the mechanism of the foot, and yet no one disputes the statement that the natural

* Those who wish to go into the matter more fully might consult Ellis, 'On the Human Foot,' and Arbuthnot Lane, 'Guy's Hospital Reports,' 1887.

method of running is from 'toe to toe.' Certainly no one who has tried would deny that it is the better method.

The fast walking, that is seen in athletic sports, may be brought forward as an argument that in walking the heel should reach the ground first; for, according to the laws of all walking matches, the progression must be 'fair heel and toe,' that is to say, the heel of one foot shall reach the ground before the toes of the hinder foot have left it. But fast walking is a purely artificial method of progression founded upon false notions of the natural method of walking. Let any ordinary person try to walk very fast, and what is the result? He invariably runs; he lifts the hind foot off the ground before the front foot has reached it. Running, then, is the natural method of quick progression. We find a proof that fast walking, as performed in matches, is unnatural in the fact that compared with running, it entails a very severe strain upon the performer, and has but few devotees. Indeed, at a series of athletic sports it is the exception to find a walking race included.

In dancing and running it is imperative to bear the weight of the body on the toes, not only to perform these actions with grace and freedom, but also to prevent the fatigue that inevitably follows when the weight of the body is borne on the heels. In all athletic exercises, such as boxing and fencing, the first business of the master is to teach the pupil how to use his feet—in other words, to spring on and off his toes. Is it only in walking, then, that we are to reverse the law, and pound away on our heels instead of springing forward on our toes?

Civilization has fixed upon a certain ideal in the shape of boots that necessitates an alteration in the natural mode of walking. Children when learning to walk are always told to turn their toes out, and often in consequence turn their heels in and knock their internal malleoli together; so they are next taught to keep their heels apart, which object is obtained by separation of the feet and farther abduction; or if they are not taught to walk improperly, wearing ordinary boots will practically compel them to do so.

A person who has been taught to walk in this civilized manner, and who has worn an 'artistic' boot, will no doubt whilst crossing a room with bare feet, touch the ground with his heels first as he

walks with feet abducted. Let him try to walk with toes first to the ground, with feet straight in front or very slightly adducted. At first it will be a tiresome mode of progression, and may even appear awkward, but soon he will become accustomed to it and it will be natural to him. What a difference between the two methods! Compare the firm, elastic, springing step of the one, with the heavy, inelastic tread of the other. Why should we persist in taking as our model the lifeless, shambling gait of the flat-footed cripple, to whom feet are more of an encumbrance than an aid in locomotion?

'How manifold,' says Mr. Hancock, 'are the functions of the human foot! However hard the labour, whatever the weight to be carried or drawn, whatever the distance to be walked or run, whatever the space to be leapt or the height to be climbed, the foot has also and always to sustain the superimposed human frame. Not as a mere solid immovable mass, but with a fostering though firm elasticity, without which these several actions could never be performed, save with an amount of jarring and concussion as would inevitably destroy the brain, spinal marrow, etc.'

All agree with the above statement so admirably expressed by Mr. Hancock, yet even he himself would deprive the mechanism of the foot of its 'fostering' care in its most ordinary duty of everyday life; for, in describing the method of progression in walking, he states that the heel should come first to the ground. The part of the foot that first reaches the ground must of necessity be the part which communicates the shock to the leg, though that is not the moment at which the foot is subjected to the greatest pressure. Admitting, then, that the foot is admirably constructed to perform its functions with the least amount of jarring possible to the body, why should we in walking, in which we most often call its functions into action, use it in such a manner that we subject ourselves to the greatest amount of jarring possible instead of the least?

For the purpose of walking, the anterior muscles must be looked upon as flexors or tractors of the leg on the foot rather than as extensors of the foot on the leg; that is to say, we must regard the distal attachment of the anterior muscles as the more important fixed point from which they act. Anatomists, by naming

them extensors, have tended to give a false impression of their true action, which we may state briefly to be this—acting from the toes as fixed points, which are held firmly to the ground by the posterior muscles, they pull on the leg and bring it over the foot. This may be described as the first stage in walking, and as what occurs after the toes have reached the ground and before elevation of the posterior portion of the foot has commenced.

During the second stage of walking, *i.e.*, during the elevation of the heel, these muscles, acting from their attachment to the leg bones, pull on the toes, and fix them for the posterior muscles to act from. The action of the tibialis anticus and peroneus tertius is of the same nature as the so-called extensors.

The action of the posterior muscles must be looked upon as lifting the posterior part of the foot off the ground, and holding the anterior extremity of the foot to the ground, thus assisting the anterior muscles in flexing the leg on the foot by providing them with a steady fixed point to pull from. While thus acting, the posterior muscles elevate the posterior part of the foot and propel it forward. Instead of being flexors of the foot on the leg, as their name would imply, they are 'elevators' of the posterior portion of the foot and propellers of the whole foot forwards.

As was pointed out by Meyer, a straight line drawn backwards through the middle line of the great toe in an unspoilt foot should pass through the centre of the heel. On the dorsal surface this corresponds with the line of the extensor proprius hallucis, and 'marks the principal line of action in the foot' (Ellis; see Fig. 9).

Meyer's line, extended as indicated by dots in Figs. 25 and 26, is the 'line along which the body is drawn principally by the action of the tibialis anticus, acting from the inner margin of the foot, and the extensor muscles acting from the toes as fixed points. It is the line along which the body is propelled by the powerful long flexor of the great toe, assisted by the tibialis posticus and long flexor of the smaller toes which pass with it round the inner side of the ankle, assisted also by the two peronei which pass round the outer side of that joint. It is, in fact, the line of traction forward when

the body is behind the foot, of propulsion onward when the body has passed over it.'

'On looking at this diagram,' says Mr. Ellis (Fig. 25), 'it may be observed that this line does not accord with that in which the body is supposed to be moving. No, but it does point directly

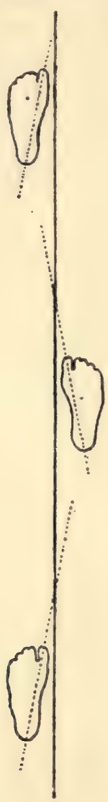


FIG. 25.—WALKING WITH FEET ADDUCTED.

FIG. 26.—WALKING WITH FEET ABDUCTED.

(After Ellis.)

towards the spot on which the right foot is to fall, over which the centre of gravity must for a time be. The right foot does literally *fall* on this spot, and in the position indicated by the diagram. The toes are inclined inwards because the ankle has

been thrown outwards as the foot became extended in rising to tip-toe. The foot is now in the position of rest, and all the muscles concerned in propelling the body onwards having relaxed, the rest is complete.'

'Thus the most complete rest possible is given to the foot which has just borne the strain of having the body propelled onwards from it. The foot is also in the position adapted for falling into the proper place for the next step without muscular effort in placing it. In this way, "foot-fall" is, as it should be, something more than a figure of speech.'

'Such rest as can be obtained in the intervals between steps may seem to be a small matter; the period during which the foot is uplifted from the ground seems so small as to be of no appreciable value for rest. This is not really so. The muscles concerned in respiration get no rest beyond that obtained between the inspirations; the heart, only that between the beats. Yet rest of muscular action is necessary, and is in each case sufficiently supplied. The slight interval of complete rest is important, too, for the ligaments, and it is highly desirable that it should be as complete as possible.'

If the foot, however, be swung forward in a position of abduction, Fig. 26, some muscular effort is necessary to maintain it in that position, and therefore energy is unnecessarily spent and the foot muscles do not obtain any respite from their labours. The reasons given in Dr. Parkes' book for the abducted position are thus ably disposed of by Mr. Ellis. 'First, as to the increased base of support; the gain in this respect must be in a forward and outward direction. But when the one foot is lifted from the ground, the centre of gravity falls on the inner side of the other; where, then, is the advantage of having turned the toes of that foot outward, where support is not wanted, away from the middle line of the body, where it is specially needed? The increased area of support is required on the same side as the uplifted foot. Secondly, 'the feet can advance in a straight line.' This seems to imply that there is less risk of the foot which swings forward striking the ankle of the other leg. But the mechanism of the ankle-joint which throws outwards the ankle of the foot that has risen to tip-toe (the position it has assumed at the time when the other passes by), provides sufficiently against collision. More-

over, if the toes be turned out, the heel must be turned in, and be, consequently, directed towards the ankle of the other foot. Of two men walking in a dirty path, one turning out his toes, one putting them straight before him, the former will be found to have left more mud on the trouser legs opposite the ankles, showing the greater rather than the less disposition to brush the uplifted against the opposite ankle. Thirdly, it is only admitted to be 'doubtful' whether with the toes in front there is any increased spring from the great toe, and it is alleged that the position involves a loss in this respect as regards the other toes. Now, taking the great toe as the base from which the body is to be propelled onward, it is, when directed slightly inwards, in line with the direction in which the body has to be carried, and in line with the tendon of the long flexor muscle which propels it. On the other hand, when turning out, it is oblique in relation to both. As to the smaller toes, they have little to do with the forward spring; their function has been explained to be that of gripping, but in direct proportion as they are turned out, the line of propulsion is oblique as regards them.'

Another matter of dispute amongst various writers is the question whether the foot lengthens or shortens during walking. Above we have shown that the inner edge lengthens when the foot is abducted, and shortens when the foot is adducted. In the first stage of walking we can account, then, for the contradictory statements that have been made as regards the lengthening or shortening of the foot, for it resolves itself into the question, Does the person walk with heels first to the ground and the feet abducted, or does he walk with toes first to the ground and the feet adducted slightly, or placed directly forwards? In the former case there will be lengthening of the inner edge, in the latter shortening. In both instances, however, when the heel is lifted off the ground, and the weight thrown on to the toes, the arch even in abduction is rendered more marked, and the length of the foot on the inner side is diminished. This may be easily proved by placing a tape under the sole of the foot, and holding one end at the posterior portion of the heel at a point in the middle line. If, now, the person be directed to stand on tiptoe, the tape will be distinctly slackened, showing that the length of the foot is diminished (Ellis). This shorten-

ing will be most marked when the foot is adducted, least so when abducted. Again, as Ellis points out, 'everyone who wears slippers knows, if they be ever so little too long, that their heels fall down as the heel of the foot is raised.' The same fact is rendered evident when dancing or running. Shoes that seem to fit when just put on are found to be too loose to run and dance in on tip-toe.

Though the question of the antero-posterior diameter of the foot has been a matter of some dispute, all are agreed that a slight increase in breadth occurs when the weight of the body is thrown on to the toes. This takes place about the external cuneiform bone as a centre. This bone articulates with the bones on either side, especially the cuboid, by a concavo-convex surface; and the facet on the anterior surface of the scaphoid is also slightly convex from above downwards, allowing more movement with the external cuneiform than with the other cuneiform bones (Humphry). The increase in breadth is, however, a scarcely measurable quantity.

Which are the muscles that are brought into action when we stand on tip-toe? or, rather, which are the muscles most concerned in the act?

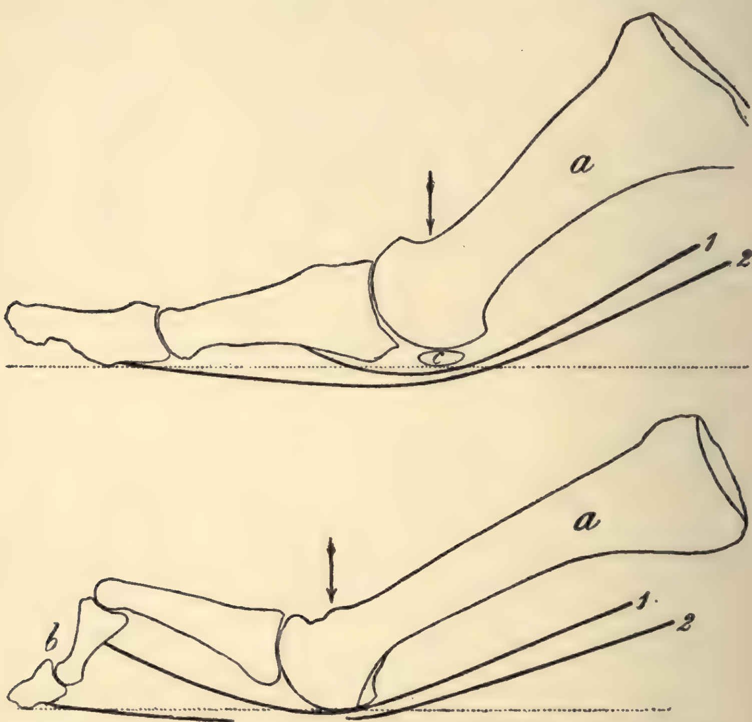
The soleus and gastrocnemius by means of the tendo Achillis are certainly very powerful factors; but they are by no means the only muscles concerned, as some authors would lead us to think, and as many people carelessly imagine. The tibialis posticus, the long flexor of the hallux, and the long flexor of the toes, the peroneus longus and brevis, and the small muscles of the sole, are all more or less concerned in raising the body to tip-toe.

The small muscles of the hallux, viz., the abductor, adductor, and flexor brevis, have a very important action, in that, all acting together, they hold down the first phalanx, the fulcrum being formed at the metatarso-phalangeal joint of the great toe (Fig. 27), this joint being pushed downwards by the weight of the body.

The first phalanx being held down, the long flexor, acting on the second, exerts its influence on a straight great toe. 'In the other digits there is nothing to prevent the joint between the first and second rising up, and it does so as the toes are drawn firmly against the ground by the long flexor muscle (Fig. 28),

the function of the smaller toes being partly to grip the ground' (Ellis).

'The office of the toes is to enlarge the area of the foot, to adapt it to irregularities of surface, enabling it to cling to the ground, to prevent slipping, and to assist in climbing. They




FIGS. 27 and 28.—Show, in the Great Toe and in the Smaller Toes, and Heads of Metatarsal Bones ($a$) borne down by the weight of the body, indicated by arrows, and the phalanges (two in the case of the great toe, three in the case of the smaller) acted on by the Muscles shown by lines. 1 is the flexor bevis, 2 is the flexor longus. The great toe is held flat and the smaller toes have a depression at $b$, $c$ is a small sesamoid bone not usually found in the smaller toes. (After Ellis.)

also afford to the flexor muscles an opportunity to give a last impulse to the step before the foot is withdrawn from the ground.' (Humphry).

The long flexor of the great toe having a firm point to pull

from anteriorly, and acting posteriorly from a point where it grooves the tibia in a line with the middle point of the heel, tends, by its contraction, to approximate the two extremities of the foot. It thereby increases the arching of the instep 'like a bowstring' (Figs. 29, 30). The long flexor of the toes enters the foot at a higher level than the long flexor of the hallux, and, crossing beneath the latter, picks it up, as Ellis puts it, and, when contracting, tends to throw it upwards, an action which this author


FIG. 29.


FIG. 30.

These figures are to show that the muscles which raise the body on tiptoe at the same time increase the curve of the plantar arch. 1. Flexor longus hallucis. 2. Tibialis posticus. 3. Gastrocnemius. 4. Tibialis anticus. (After Ellis.)

says may with greater propriety be compared to a tie-rod than to a bowstring.

The tibialis posticus, besides throwing up the posterior part of the foot, tends to elevate the inner edge, and so inverts the sole; it draws the scaphoid bone towards the sustentaculum tali, and so throws upwards and outwards the head of the astragalus, which rests on the ligament between those bones. The long flexor of the great toe has also a slight inverting action.

The peroneus longus, acting from the outer side, has a very

important function in maintaining the arching of the foot. Duchenne even goes so far as to say that it forms the arch, and that flat-foot is due to weakness of this muscle alone; but this is undoubtedly an exaggeration. It crosses the foot from the outer side, and is attached to the base of the first metatarsal bone, and therefore tends to cause eversion of the sole at the same time that it elevates the posterior part of the foot. The resultant of the inverting action of the muscles on the inner side of the ankle and the everting action of the peroneus longus on the outer side is that these muscles acting together assist in raising the heel.

There is one important fact about the action of the tendo Achillis to which Humphry thus refers: 'The point to which the tendon is attached is on a line with the ankle-joint and with the middle of the balls of the toes, and the effect of the muscle is simply to raise the heel vertically. If the point of the heel be inclined a little to either side by twisting of the foot, the muscle will increase the amount of the deviation at the same time that it raises the heel.'

**Boots.**—We can hardly expect to introduce such a complete reformation in the modern boot as Mr. Ellis sets forth in his monograph; but without going to such lengths as he suggests, we may insist upon the desirability of a straight inner edge, a low heel, and a flat sole, following out the lines of the plantar surface, without trespassing too much on the modern ideal of what is beautiful in a boot. If these three points could be gained, a great stride would be made towards a rational clothing for the foot. We would refer those who wish to go more fully into the subject to Mr. Ellis's monograph on the Human Foot. Many people advocate a so-called straight inner edge, but that only means a straighter edge than the median pointed boot which even now is in vogue in some quarters, and still entails a slight valgus position of the great toe.

The reproduction of the natural outlines of the sole without any spring in the last, and a straight inner edge, would allow the foot to perform its normal functions without serious impediment. The danger of high heels lies, first, in the fact that people are apt to walk on them, and, secondly, that the muscles which elevate the posterior part of the foot are placed at a disadvantage,

and the heel being continuously elevated, the propulsive action of the sole muscles is to a great extent lost.

Carrying out the false principles involved in the ordinary method of walking, *i.e.*, with heels first to the ground, bootmakers put a spring in the last; that is to say, they make the sole slant upwards and forwards from the balls of the toes. The necessity for this spring is increased by a high heel, and the bootmakers generally recognise this fact, by making the boots with the highest heels with the highest spring, it being least evident in slippers without heels. In order to justify this procedure, bootmakers point out that in boots that have been worn this spring is increased, but it is only increased by reason of the fact that the persons have walked with heels first to the ground, rocking themselves, as it were, on to their toes. Finally, as if to prevent any reproduction of the original form of the foot, both sides of the boot are frequently made almost exactly alike. As a result of all this artificial adaptation of the shape of the foot to that of the boot, hosts of minor and major evils arise, and flat-foot, genu valgum, hallux valgus, bunions, corns, become the commonest of the evils that flesh is heir to.

## CHAPTER II.

### TALIPES, OR CLUB-FOOT.

THE term 'talipes' (*talipedo*, to walk on the ankles; from *pes* and *talus*), originally restricted, as its derivation implies, to that form of severe varus in which the patient appears to walk on his ankles, has, since the time of Dr. Little, been extended as a generic term

FIG. 31.—TALIPES EQUINUS. (From a photograph of a patient attending the Orthopædic Department of St. Bartholomew's Hospital.)

to various deformities of the foot. The deformities designated talipes are usually divided into four or five classes—namely, varus, equinus, valgus, calcaneus, and sometimes cavus—and into subclasses or compound varieties, such as equino-varus, equino-valgus, calcaneo-varus, calcaneo-valgus.

The distortions comprehended under the term 'talipes' have all this much in common, that the deformity may be said to

consist in the pathological fixation of the foot in a position into which or towards which it can be drawn by the normal physiological contraction of certain muscles; while the centres of motion at which the displacement occurs are centres of normal movement in the healthy foot. Thus, in talipes equinus (Fig. 31) the foot is fixed in a position of plantar flexion, a position in which it can be placed by the normal contraction of the great calf muscles. The heel is raised, the toes point to the ground, and on these the patient walks. In talipes calcaneus (Fig. 32) the foot assumes the position of dorsal flexion—a position into which it may be drawn by the anterior muscles of the leg. The

FIG. 32.—TALIPES CALCANEUS. (From a photograph of a cast (No. 75*a*) in the Museum of St. Bartholomew's Hospital.)

heel touches the ground, whilst the toes are raised. In both of these varieties the chief centre of movement, where the displacement of the bones occurs, is, as in the normal movement of the foot, chiefly at the true ankle-joint, though, as explained hereafter in detail, secondary changes occur at the transverse tarsal joint.

In talipes varus (Fig. 33) the foot is held in an inverted and adducted position, combined with some plantar flexion—a position it can be made more or less to assume by the contraction of the

tibial or adductor muscles and muscles of the calf. The sole looks inwards, the outer border of the foot downwards; the toes point towards the middle line, and the heel is raised. In talipes

FIG. 33.—PHOTOGRAPH OF A CASE OF CONGENITAL VARUS IN A CHILD OF SEVEN YEARS, ATTENDING THE ORTHOPÆDIC DEPARTMENT OF ST. BARTHOLOMEW'S HOSPITAL.

valgus (Fig. 34) the foot is abducted; the outer edge may be raised whilst the sole may be flattened. Into this position the foot

FIG. 34.—TALIPES VALGUS (FLAT-FOOT). (From a photograph of a patient in the Orthopædic Department of St. Bartholomew's Hospital, taken by Mr. Clindening.)

may be, to some extent, drawn by the contraction of the abductors or peronei. In these two varieties the chief centre of movement

is at the sub-astragaloid and transverse tarsal joints, and to some extent at the ankle-joint proper.

FIG. 35.—TALIPES CAVUS. (From a photograph of a patient in the Orthopædic Department of St. Bartholomew's Hospital, taken by Mr. Clindening.)

FIG. 36.—PARALYTIC TALIPES EQUINO-VARUS. (From a photograph of a cast (No. 94*a*) in the Museum of St. Bartholomew's Hospital.)

In talipes cavus (Fig. 35) the arch of the foot is unnaturally increased, a condition that may be normally brought about to

some extent by the contraction of the plantar flexors and short muscles of the sole; the chief centre of movement here is at the transverse tarsal joint.

In the compound varieties also, the position of the foot is likewise one into which the foot can be drawn by the combined contraction of those muscles which, acting alone, produce the simple form. Thus, in equino-varus (Fig. 36) the foot is not only plantar-flexed, but also adducted; in equino-valgus (Fig. 38) plantar-flexed and everted; in calcaneo-valgus (Fig. 37) dorsal-flexed and everted, and so on. Again talipes equinus, and

FIG. 37.—PARALYTIC CALCANEO-VALGUS. (From a photograph of a patient in the Orthopædic Department of St. Bartholomew's Hospital, taken by Mr. Clindening.)

its compound variety, equino-varus, and talipes calcaneus, etc., may be combined with talipes cavus. Indeed, so often is talipes cavus combined with equinus and calcaneus that, by some authors, it is regarded as a mere complication, or even as an essential part of the above-named deformities.

The deformities assumed by the foot, then, are those into which it can be drawn by the normal physiological contraction of the muscles; and the alteration in the relation of the bones at the centres of movement are those, or an exaggeration of those, which normally occur thereat.

But although the foot can be made more or less to assume, by normal muscular contraction, these deformed positions, we are not for one minute upholding the view that the deformities are primarily the result of spasmodic contraction, or indeed, in some forms, dependent in any way on muscular contraction at all. Further, we would at once point out that the deformity depends not, as a rule (although it may in some cases do so) upon the

FIG. 38.—PARALYTIC EQUINO-VALGUS. (From a photograph of a patient in the Orthopædic Department of St. Bartholomew's Hospital.)

contraction of muscles, but rather upon shortening of ligaments, and alteration in the articular surfaces and shape of the bones, especially when the deformity is severe or of long standing.

The term 'club-foot,' which was originally given to the deformity known as talipes varus because of the club shape of the lower extremity when the distortion of the foot was severe, is also used by some authors as an English equivalent for talipes.

In no sense, however, can flat-foot, talipes valgus, or spurious valgus, as it is sometimes called, be termed club-foot, and so with certain other of the deformities that will be hereafter described. The term 'club-foot,' therefore, will be here restricted to talipes varus.

The various deformities will be divided into the congenital and the acquired. The congenital are those that are present at birth; the acquired those that may occur any time afterwards. The causation of the congenital deformities is discussed at length under Congenital Varus, or club-foot, the most common form of congenital talipes. The acquired are in by far the greater number of cases due to infantile paralysis; but there are many other causes which will be discussed under the head of each variety.

As regards the relative frequency of talipes, congenital talipes varus, or, as it is called by some authors, equino-varus, is the most common form of congenital talipes. Amongst the acquired varieties, talipes valgus, flat-foot, or spurious valgus as it is sometimes termed, is most often met with. Talipes equinus as a congenital deformity is rare. We have only met with two cases during twelve years in the Orthopædic Department. As an acquired affection it is common, especially as the result of infantile paralysis, and is then frequently combined with more or less varus, sometimes with valgus, and often with cavus. Pure congenital valgus is rare. Its occurrence is denied by some. What we here regard as equino-valgus and calcaneo-valgus, that is, as varieties of equinus and of calcaneus respectively, are considered by some authors as varieties of valgus, the valgus being looked upon by them as the more essential feature, and the plantar or the dorsal flexion as accidental conditions depending upon a contraction or relaxation respectively of the tendo Achillis. Talipes calcaneus both as a congenital and as an acquired condition is comparatively speaking rare. Of the two, the acquired is the more often met with. The compound varieties of calcaneus are also rare.

Talipes cavus seldom occurs as a congenital affection. As an acquired it is sufficiently common and is frequently combined with equinus, equino-varus, calcaneus and varus.

Pure acquired talipes varus is rare, an acquired varus position

being nearly always combined with equinus, of which it is regarded by us as a variety (equino-varus).

Other classifications of the above described deformities have been proposed, but we shall adopt the above as the oldest and best known. By Duval the term stréphopodie is used as a generic term, whilst the term stréphocatopodie is employed for equinus, stréphoanopodie for calcaneus, stréphendopodie for varus, and stréphexopodie for valgus. By Bonnet the deformities are divided into two main classes according to the innervation of the muscles, namely, internal popliteal club-foot and external popliteal club-foot, the internal including varus and equinus, the muscles which draw the foot into these positions being supplied by the internal popliteal nerve; the external including valgus and calcaneus, the muscles which draw the foot into these positions being supplied by the external popliteal nerve. The tibialis anticus, which is also concerned in varus, is, however, supplied by the external popliteal nerve, one fact, at least, that militates against Bonnet's classification.

## CHAPTER III.

### TALIPES VARUS OR EQUINO-VARUS.

Talipes Varus or equino-varus is divided into congenital and acquired.

#### Congenital Talipes Varus.

**Synonyms.**—Congenital talipes; Equino-varus; Congenital club-foot; Pes varus; Piedbot varus; Piedbot varus congénital; Klumpfuss; Piedo varo.

**Definition.**—Congenital talipes varus is a deformity in which the foot is plantar-flexed at the ankle-joint, and adducted and rotated inwards at the transverse tarsal and subastragaloid joints. Hence some surgeons, seeing that there is always an elevation of the heel (equinus) as well as inversion of the foot (varus), call the deformity equino-varus. We, however, prefer to follow Mr. Adams and others in calling the deformity talipes varus, and reserving the term equino-varus for cases of equinus in which there is, so to speak, an accidental turning inwards of the foot, the essential condition being the equinus, and the varus being merely superadded. The deformity under consideration, though consisting of both an elevation of the heel and also of a turning inwards of the forepart of the foot, is in itself an entity, both conditions, the equinus and the varus, being essential factors; hence we call it simply talipes varus.

**General Description of the Deformity.** — Congenital varus is characterized (Fig. 39) by an elevation of the heel, and an inversion and twisting of the front part of the foot. The toes point inwards; the sole looks backwards and the dorsum forwards; the inner border is raised and unnaturally concave, and the outer border is convex, rounded, and turned towards the ground.

Most children are born with the feet in a condition of slight varus.

The deformity may consist of little more than a mere exaggeration of the normal varus condition at birth, or of every degree of severity up to an extreme distortion in which the dorsum of the foot not only looks forwards as described above, but may be turned towards the ground, or even look backwards, whilst the inner border of the foot may be drawn into contact with the leg (Fig. 42).

But the appearance of the foot differs not only according to the degree of the deformity, but also according as the foot has or has not been used in walking. We shall, therefore, describe

FIG. 39.—CONGENITAL TALIPES VARUS. (From a photograph of a patient attending the Orthopædic Department of St. Bartholomew's Hospital.)

the deformity as it appears (1) in the infant at birth, or before the foot has been walked on, and (2) after the foot has been walked on and in inveterate cases in the adult.

### I. APPEARANCE OF THE DEFORMITY IN THE INFANT, OR BEFORE THE FOOT HAS BEEN USED IN WALKING.

It has already been stated that the deformity may consist of little more than an exaggeration of the inward inclination of the foot at birth. From this condition it may pass through every shade of increasing severity short of the extreme degree of dis-

tortion met with in the foot which has been used in walking, and in which the bones in transmitting the weight of the body to the ground have been still further altered in shape and forced or drawn into yet more abnormal positions. We shall therefore for the purpose of the better describing the treatment, prognosis, etc., divide the deformity into degrees. We admit that such a division is artificial, as the various degrees of severity pass insensibly into each other. It, however, appears to us a useful one, and we shall adopt it.

Before treating of these degrees, we will first describe a typical case, *i.e.*, one of moderate severity.

The whole foot appears smaller than normal, the heel is drawn upwards and is poorly developed, and the tendo Achillis feels tense. In consequence of the elevation of the heel, the whole foot is in a position of plantar flexion; hence the dorsum of the foot looks forwards and upwards instead of upwards. The anterior part of the foot is adducted and inverted, so that the toes point inwards, or inwards and slightly upwards in a direction more or less at a right angle to the leg, whilst the inner border looks upwards, the outer border downwards, and the sole backwards and downwards.

The inner part of the sole and inner border of the foot are unnaturally concave, the outer border is rounded and convex. On taking hold of the foot and endeavouring to bring it into a line with the leg, the tendons of the tibialis anticus and posticus are found to be tense, and bands of fascia may be felt on the inner side of the sole. In the slighter degrees of the deformity, the above described condition is less marked, and on manipulation with the hand the foot can be brought into, or almost into line with the leg; but the heel cannot be brought down, and the foot cannot be carried to or beyond a right angle with the leg.

In severe cases, on the other hand, the foot may be so inverted and rotated that the inner border may be in contact with the leg; whilst the dorsum may look directly downwards, or even backwards and inwards, and the toes point directly upwards.

1. **The Size and General Appearance of the Foot.**—The deformed foot is always smaller than the normal foot of an infant of the same age, its small size being very apparent when the deformity is unilateral and the feet can thus be compared (Fig. 39). The

foot as a whole presents a rounded, shortened, and peculiarly-twisted appearance. The rotundity is due to the convexity of the outer border and dorsum of the foot; the shortening to the bending of the foot at the transverse tarsal joint, and to the actual diminution in the size of the bones; the twisted appearance to the combination of plantar flexion at the ankle with adduction and rotation of the anterior part of the foot. The dorsal surface is somewhat irregular and uneven, a well-marked depression being seen and felt over the situation of the outer

FIG. 40—PHOTOGRAPH OF A CASE OF CONGENITAL VARUS IN A MALE CHILD, AGED SIX MONTHS. (The left foot being farther removed from the camera than the right seems somewhat smaller, but both are of the same size.) By Mr. Clindening.

Neither foot can be brought into a line with the leg, and the equinus position strongly resists any attempt at reduction. The right foot was more resistant than the left, and after one month's treatment with plaster of Paris a syndesmotomy was performed on the right foot, and the tendo Achillis divided at the same time. The anterior part of the foot was then easily brought into a line with the leg, but the equinus position was but little reduced. The left foot was still under treatment with plaster, the varus being satisfactorily overcome, but the equinus not much reduced.

surface of the inwardly-deflected neck of the astragalus, whilst two hillocks are produced by the projections of the unopposed outer part of the rounded head of the astragalus and anterior

end of the os calcis. The plantar surface is unnaturally concave, and on account of the doubling backwards of the anterior on the posterior part of the foot appears shorter than normal. The external malleolus can always be well felt, but the internal malleolus is more or less buried by the inversion of the anterior part of the foot and approximation to it of the scaphoid bone. It hence appears less prominent than natural, and is not easily felt. The external malleolus seems to be displaced downwards and backwards, but this is entirely owing to the abnormal position of the os calcis, and is altogether deceptive.

2. **The Elevated and Ill-developed Condition of the Heel.**—The heel is always elevated to some extent (except, perhaps, in the slightest degree of the deformity), and is very poorly developed and of small size. The tuberosity of the os calcis does not stand out prominently as in the normal foot, but can be felt drawn upwards behind the fibula. The small size of the heel is partly the result of the os calcis having a more or less vertical position, and partly the result of the bone being but imperfectly developed in its posterior half. The tuberosity of the os calcis has been said to be nearer to the internal malleolus than normal. In all the cases we have examined the position of the tuberosity has been the reverse of this. We have always found it nearer the external than the internal malleolus, and in severe cases drawn distinctly upwards and outwards behind that process. Such a position agrees with what is found in the dissected foot, where the os calcis has always an oblique position, being drawn not only upwards, but also rotated at the same time on its long axis, so that whilst its anterior end is directed abnormally inwards, its posterior end, or tuberosity, is carried outwards towards or behind the external malleolus.

3. **The Condition of the Tendo Achillis.**—The tendo Achillis is invariably felt to be tense and contracted, and, in correspondence with the outward rotation of the tuberosity of the os calcis, is nearer the fibula than in the normal foot. It has been said* that the tendon in congenital varus lies over the course of the posterior tibial artery. We agree with Mr. Adams, however, that this is not the case, but that the tendon, in place of lying over the course

* Rédard, 'Traité Pratique de Chirurgie Orthopédique,' Paris, 1892.

of the artery, is more removed than usual to the outer side of the vessel.

**Degrees of the Deformity.**—*First degree.*—In this degree the foot is only slightly inverted, and the os calcis is little, if at all, elevated. The deformity, in fact, is little more than a slight increase of the normal inward inclination of the infant's foot at birth. On taking the foot in the hand, it can be completely restored to its natural shape, though it cannot be so completely dorsal-flexed as the foot of the other side. It falls back again into the deformed position when the hand is removed. The obstacle to reduction lies chiefly in the resistance of the tibial tendons and tendo Achillis.

FIG. 41.—RELAPSED CONGENITAL VARUS. (From a photograph of a cast (No. 78*a*) in the Museum of St. Bartholomew's Hospital.)

*Second degree.*—In this degree the deformity, though not severe, is well marked. The foot turns distinctly inwards, and the os calcis is more or less elevated. When taken in the hand, the foot cannot be brought completely into line with the leg without considerable force, nor can the heel be brought down and the sole placed flat on the ground. The resistance to reduction is partly due to the contraction of the tibial tendons, tendo Achillis and plantar fascia, and partly to the shortening of the ligaments on the inner side of the foot and behind the ankle. The appearance

of the foot is that described as typical of the deformity (see p. 50).

*Third degree* (Fig. 41).—In this degree the inversion of the foot is still more marked, and the heel is considerably elevated. On taking the foot in the hand, the inversion cannot be overcome, nor can the heel be brought down. On attempting to correct the deformity, the tibial tendons, the tendo Achillis, and the plantar fascia are felt tense. As in the preceding degree, the foot presents the

FIG. 42.—PHOTOGRAPH OF A SPECIMEN OF EXTREME CONGENITAL VARUS FROM A STILL-BORN CHILD (FRONT VIEW). (From St. Bartholomew's Hospital Museum, No. 3511.)

appearance already described as typical of the deformity; but this degree differs from the former in that the foot is more rigidly held in the deformed position, and cannot be so nearly rectified by manual force. The resistance to reduction lies not only in the tendons, but also and chiefly in the ligaments, and partly in the bones.

*Fourth degree* (Fig. 42).—In this degree the inversion of the foot is extreme, the inner border of the foot forming an acute angle with the leg, or even being in contact with the side of the leg.

The heel is greatly elevated, the os calcis having a nearly vertical position. The dorsal surface of the foot looks downwards as well as forwards; the plantar surface in consequence of the contraction and shortening of the plantar fascia is markedly concave and shortened, presenting a deep transverse depression across the sole. The great toe, in consequence of the contraction of the long and short flexors, is drawn away from the other toes. On taking the foot in the hand, no improvement or very little can as a rule be brought about.* The tibial tendons, the tendo Achillis, and the plantar fascia are felt to be very tense. The resistance to reduction lies to some extent in the contraction of the tendons, but chiefly in the shortened ligaments and abnormal shape of the bones.

Under this degree may be described an intractable form of club-foot. The inversion, though well marked, is not extreme. The outer border of the foot is much more convex than usual, and projects considerably beyond the outer border of the bones of the leg. If a line is dropped perpendicularly down the centre of the leg, much more of the outer part of the foot lies to the outer side of this line than in the normal foot, or even in severe degrees of varus. The foot is extremely rigid, and cannot be corrected, or hardly to any extent, by the hand. The leg is short and stumpy. Even after division of the tibials and tendo Achillis, together with the ligaments on the inner side of the foot and behind the ankle, but little improvement can be brought about. This, in our experience, is the most resistant of all forms of congenital varus, and we venture to think that in it an imperfect cure may often be prognosticated without some operation on the bones. The resistance to reduction lies chiefly in the deformity of the bones, namely, the prominence to be later referred to at the front of the external malleolar facet on the astragalus, the heaping up of bone to the outer part of the anterior end of the os calcis, the inward deflection of the neck of the astragalus, and the bowing in its long axis of the os calcis. The ligaments and tendons in our opinion play but a very subordinate part in this phase of the deformity in holding the bones in their abnormal position.

* Occasionally, although the outward deformity is extreme, the ligamentous resistance is comparatively slight, and can to some extent be corrected by the hand.

## II. Appearance of the Foot after it has been used in Walking and in Intractable Cases in Adults.

When the deformity is allowed to continue untreated and the child is permitted to walk on the foot, not only do the misshapen bones become ossified in their misshapen state, the abnormal articular facets confirmed in their abnormal directions, and the

Fig. 43.—Photograph of a Case of Congenital Varus in a Girl of Two Years—untreated. (From a patient attending the Orthopædic Department of St. Bartholomew's Hospital.)

The varus was almost completely overcome by manipulation ; but the equinus was not affected.

shortened ligaments still more shortened, firmer and more resisting, but in consequence of the weight being transmitted through the outer border of the foot, the bones are further altered and displaced. Thus, as will be shown in the section on Morbid Anatomy, the astragalus and os calcis especially become greatly altered in shape, and the anterior part of the foot markedly adducted and rotated, so that ultimately the dorsum is turned towards the ground. In a typical case the whole foot is smaller than natural and is especially diminished in length ; the dorsal surface looks forwards and downwards toward the ground

(Fig. 43), and the plantar surface looks upwards and backwards. The transverse arch is narrowed by the approximation of the fourth and fifth to the first metatarsal bones, and a longitudinal and a transverse furrow more or less well marked present themselves in the sole. These furrows are the result respectively of the narrowing of the transverse arch and the bending backwards of the fore-part of the foot on the hinder portion at the transverse tarsal joint. They are characteristic, as pointed out by Mr. Adams, of congenital talipes varus, since they seldom or never occur, and then only to a very slight extent, in the acquired or paralytic variety of the deformity. The skin over

FIG. 44.—PHOTOGRAPH OF A CASE OF CONGENITAL VARUS IN A CHILD OF SEVEN YEARS (FROM BEHIND). (From a patient attending the Orthopædic Department of St. Bartholomew's Hospital.)

The longitudinal furrow is well marked, the transverse less so. The heel is considerably elevated. The calf on the same side as the affected foot is seen to be much smaller than on the other side.

these furrows is contracted and resisting, and with the shortened plantar fascia offers a further obstacle to reduction. The longitudinal furrow (Fig. 44), which extends along the anterior two-thirds of the foot, ends posteriorly at the transverse furrow, which extends obliquely across the sole about the junction of the middle with the posterior third of the foot (Fig. 47).

Over the outer and dorsal surface the skin with the underlying cellular tissue becomes thickened, forming callosities, and beneath these over the prominent points of bone, bursæ sooner or later form, and as in other situations are liable to become inflamed and distended with fluid, causing great inconvenience and lameness. In old and neglected cases corns and ulcers may occur over the seats of pressure (Fig. 46). The skin over the heel, on the other hand, remains thin and delicate, and the cellular and adipose tissue ordinarily forming the pad in this situation is commonly defective. The heel itself, as in the infantile cases, remains small and imperfectly developed. The whole foot appears markedly shortened, and the movements at the ankle

FIG. 45.—CONGENITAL TALIPES VARUS. (From a drawing of a patient in the Orthopædic Department of St. Bartholomew's Hospital, by Mr. Parker.)

and other joints become more and more restricted. The whole limb, and especially the leg below the knee, is more or less wasted, and at times shortened half an inch or more. The ligaments of the knee are frequently relaxed, allowing the leg to be rotated inwards. In a specimen we examined, the neck of the femur was also deflected and set on the femur at such an angle as to allow the whole limb to be rotated abnormally inwards.

Although children with unilateral club-foot may walk and run with, comparatively speaking, very little lameness and incon-

venience, as they grow older the lameness generally increases in consequence of the advancing rigidity at the ankle and other joints of the foot; while the feet may become tender, bursal troubles occur, corns form, the callosities become inflamed, and ulcers appear over the prominent points of bone or in connection with the inflamed bursæ. In consequence of the defective

FIG. 46.—PHOTOGRAPH OF A CAST OF DOUBLE CONGENITAL VARUS IN A CHILD AGED SEVEN YEARS (FRONT VIEW). (Cast No. 83*a*, St. Bartholomew's Hospital Museum.)

The calf muscles are much wasted. The whole limb, especially the left, is rotated inwards both at the knee and hip. Large callosities and bursæ are seen over the prominent points of bone.

vitality of the bone, these ulcers are very difficult to heal, and nothing may remain but for the patient to go about on crutches or lose his leg. When both feet are severely affected, as in the patient from whom the cast shown in Fig. 46 was taken, the peculiar foot-over-foot method of progression is very characteristic,

each foot having to be lifted over the other to prevent the toes catching as one leg after the other is carried forward in walking. When one foot only is involved, the shortening of the affected limb, which generally occurs if the patient is not treated, adds to the lameness. Mr. Adams speaks of the deleterious effect that the deformity may have upon the mind, but it does not

FIG. 47.—PHOTOGRAPH OF A CAST OF CONGENITAL VARUS IN A CHILD SEVEN YEARS OF AGE (BACK VIEW). (Cast 83*a*, St. Bartholomew's Hospital Museum.)

The transverse furrow on the sole of the foot is well marked.

appear to us to have a greater influence in this respect than any other deformity or bodily defect.

**Relapsed and Uncured Cases.**—Many of the so-called 'relapsed' cases would be better spoken of as 'uncured.' Relapses after the complete restoration of the foot to its normal shape and functions may of course occur if the after-treatment is

inefficient or neglected, or is not continued sufficiently long. In the majority of relapsed cases, however, that have come under our notice, careful inquiry elicited the fact that the deformity had never been completely cured. Either the varus

FIG. 48.—PHOTOGRAPH OF A CASE OF DOUBLE CONGENITAL VARUS IN A MALE CHILD WITH CURED SPINA BIFIDA IN THE LUMBAR REGION. (From a patient attending the Orthopædic Department, St. Bartholomew's Hospital.)

There was marked paralysis and anæsthesia of the lower limbs, with incontinence of urine and fæces. Two large bed-sores had formed on the buttocks.

position had not been entirely overcome, or some unnatural concavity had been left in the sole, or the foot had never been carried in the direction of dorsal flexion beyond a right angle with the leg. The causes of relapses may be therefore divided into

two chief classes: (1) Imperfect cure; and (2) Neglect of after-treatment.

1. **Imperfect Cure.**—An imperfect cure may be the result of (*a*) Treatment having been too long delayed; (*b*) Treatment having been imperfectly carried out; (*c*) Organic changes in the muscles of the leg.

(*a*) *Treatment having been too long delayed.*—The longer the treatment is delayed the more difficult a perfect restoration of the shape and function of the foot becomes. The bones at birth are soft and pliable, consisting of little more than cartilage,* and can be readily moulded and bent as desired, and the ligaments are comparatively speaking yielding and stretchable. If the deformity is allowed to remain untreated during infancy, the bones undergo ossification in their abnormal shapes, and the ligaments become shortened and unyielding; whilst if later the child is permitted to walk on the deformed foot the secondary changes to be described in detail in the section on pathology occur—the bones undergo further alteration both in position and shape, the ligaments become further shortened, and the muscles from want of use undergo more or less atrophy and wasting. We do not mean to say that with perseverance the deformity, when thus neglected, cannot be cured; but the time required is so long, the structures on the inner side of the foot are so resisting, and the difficulty of carrying the foot beyond a right angle with the leg in the direction of dorsal flexion is so great, that too often a complete cure is not accomplished. The patient is placed in walking-irons, and active treatment practically ceases. At first the child gets about fairly well with the instrument on, but from the moment that active treatment is discontinued he begins to go back, the equinus increases, the foot gradually turns more and more inwards, and the sole becomes more and more concave. The chief causes of the difficulty in curing these neglected cases are the ossification of the astragalus with a permanent inward and downward deflection of its head and neck, the heaping up of bone about the outer side of the neck of the astragalus, and the inward deflection of the anterior end of

* The ossific centre for the astragalus appears at the seventh month, that for the os calcis at the sixth month, that for the cuboid at the ninth month, that for the scaphoid and the cuneiform bones not till between the first and the fourth or fifth year.

the os calcis. After the tibial tendons, the flexor longus digitorum, the tendo Achillis, the plantar fascia, the astragalo-scaphoid capsule, and the posterior ligaments of the ankle have been divided, the foot will still in some cases not come up to a right angle with the leg. This is due to the locking of the bones. In some cases the trochlear surface of the astragalus can be quite or almost placed in its socket on division of the tendo Achillis, but still the equinus is not overcome in consequence of the downwardly-deflected astragaloid neck. In other cases, after the tendo Achillis has been put out of court, the trochlear surface cannot be replaced because the heaping up of bone on the external part of its neck and extruded trochlear surface comes into contact with the external malleolus. If in such cases the posterior ligaments be divided, the only effect is to separate the posterior surface of the trochlea from the tibia; the anterior part cannot be forced back into place. It is too wide for its socket, and its replacement without unjustifiable violence is a physical impossibility. We have verified these facts both clinically and on the dissected specimen. Probably the only way to overcome the difficulty is either by long-continued pressure, whereby the resisting bone is gradually absorbed, or by the removal of the astragalus itself.

Again, as regards the correction of the varus after the division of the tibial tendons, astragalo-scaphoid capsule and other resisting structures on the inner side of the foot and sole, the bones can be forced into position, but the inward deflection of the astragaloid neck and anterior end of the os calcis is left untouched. As the tissues cicatrize on the inner side of the foot, there is ever a chance, unless prolonged retention in the restored position is maintained, of the bones being drawn back again round the inwardly-deflected head into the old position. Too often, as soon as active treatment is relinquished, such in many cases at once begins to take place. In our opinion, therefore, delay in the commencement of treatment is one of the chief causes of the cure being imperfect and a so-called relapse occurring.

(*b*) *Imperfections in the Treatment.*—We look upon all treatment as imperfect which does not leave the varus completely overcome, and the foot capable of dorsal flexion to the same degree as the

normal foot, or if both feet are affected to an angle of thirty degrees with the leg. When these conditions are not attained we consider the deformity uncured, and, in our experience, a relapse is sure sooner or later to occur. Failure to obtain a complete cure in our sense of the term may be due (1) to the treatment having been undertaken at too late a period; (2) to the inward and downward deflection of the neck of the astragalus, and inward bend of the anterior end of the os calcis, not having been corrected; (3) to the tibial and other tendons about the inner ankle not having been divided; (4) to ligamentous contraction on

FIG. 49.—RELAPSED CONGENITAL VARUS IN A BOY AGED SEVEN YEARS. (From a photograph of a case attending the Orthopædic Department of St. Bartholomew's Hospital.)

the inner side of the foot and in the sole not having been completely overcome; (5) to defects in the mechanical measures undertaken after operation. Mr. Adams under the head of imperfection in treatment lays stress on 'division of the tendons in the wrong order,' and 'inflammatory adhesions following clumsily performed operations, or some of the accidents, such as aneurysm, etc., which occasionally occur.'

With regard to delayed treatment as a cause of imperfect cure, we refer the reader to what has been said under that head (p. 62). Failure to overcome the inward and downward deflection of the

neck of the astragalus and inwardly-deflected anterior end of the os calcis we regard as a not uncommon cause of imperfect cure, and therefore of a relapse. Such failure may be due, as already mentioned, to treatment having been too long delayed, and the bones thus allowed to ossify in their deformed shape (see p. 62). In our opinion, it may also be due to the varus having been too rapidly overcome. In cases in which there is little alteration in the shape of the bones, and in which the deformity depends in chief part on the displacement of the scaphoid upon the astragalus, a rapid replacement is to be commended; but when there is much

FIG. 50.—PHOTOGRAPH OF A CASE OF RELAPSED CONGENITAL VARUS IN A BOY OF SEVEN YEARS OF AGE. (From the Orthopædic Department of St. Bartholomew's Hospital.)

The toes are also deformed, as seen in the photograph. The varus could be overcome by manipulation.

inward deflection of the astragaloid neck, mere replacement of the scaphoid brought about by rapid stretching, or by rupture or division of the ligaments on the inner side of the foot, leaves the deformity of the bones untouched, and we maintain that when such is the case there is a tendency, as the tissue cicatrizes, for the scaphoid to resume its faulty position, and consequently for a relapse to occur.

Neglect to divide the tibial and other tendons about the inner ankle is looked upon by Mr. Adams as one of the chief causes of relapse, and at times it undoubtedly is. Failure, however, to sufficiently stretch the ligaments on the inner side of the foot,

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which may be difficult to accomplish without the division of the tibials, is perhaps the more direct cause.

Of the defects in the mechanical measures undertaken after operation, we need hardly speak at length. In our experience, almost all such measures in slight and moderate cases are successful when intelligently and systematically employed; whilst, conversely, all will fail when intelligence and system in their application are wanting. Mr. Adams believes that one chief cause of failure is attempting to do too much at one period; that is, endeavouring to overcome both the equinus and varus at the same time. With many of the modifications of the Scarpa's and other shoes we believe that this is so; but as regards plaster of Paris we would make an exception. With this, when properly applied, the foot can be so thoroughly coaxed or forced towards the desired shape that we think no harm will come if some attempt is made to correct the equinus and the varus simultaneously; but even with plaster we must confess we have had the best results when we have followed Mr. Adams in first correcting the varus, and then when this has been accomplished, turning our attention solely to the equinus.

With regard to the order in which the tendons should be divided opinions differ. Many excellent surgeons hold that the tendo Achillis should be divided first. In slight cases this is no doubt good practice, but for the more severe we have certainly had the best results when we have divided the tibials first and the tendo Achillis only after the varus has been overcome. Mr. Adams speaks of dividing the tendo Achillis first as division of the tendons in the wrong order. We are bound to confess that this order of division has in some instances appeared to be at the bottom of the relapse or imperfect cure.

Inflammatory adhesions, we believe, play very little part in the causation of relapse. But traumatic aneurysms and the production of sloughs and other accidents of a similar kind, in that they necessarily delay the treatment, may fairly be included under the causes of relapsed cases.

(*c*) *Changes in the Muscles of the Leg.*—In rare instances some paralysis may affect the anterior or other of the leg-muscles. As a rule, the muscles in congenital varus are quite healthy, and after the cure of the deformity perform their functions in

the normal manner. In the cases, however, in which the muscles are affected, unless a retaining apparatus is worn, a relapse will occur as in ordinary paralytic varus and other deformities the result of infantile paralysis. Fortunately, paralysis in congenital varus is exceedingly rare. Mr. Walsham has only met with two cases during the whole of the twelve years he has had charge of the orthopædic department at St. Bartholomew's.

FIG. 51. — CONGENITAL VARUS WITH SPINA BIFIDA AND PARALYSIS AND ANÆSTHESIA OF LOWER LIMBS. (From a patient in the Orthopædic Department of St. Bartholomew's Hospital.)

2. **Neglect of After-Treatment.**—Neglect of after-treatment is no doubt the most frequent cause of a relapse. To ensure a satisfactory result, both physiological and instrumental after-treatment is necessary, and should be continued for some years, or until the foot shows no tendency to fall back into a faulty position and the functions of the various joints and the nutrition of the muscles of the limb have as far as possible been restored.

## ETIOLOGY OF CONGENITAL TALIPES VARUS.

The causation of congenital club-foot has long been, and still is, a fertile subject of speculation amongst surgeons and pathologists. Many theories have been advanced, and much has been said in favour of each of them. All, however, are open to some objection. They may be classed as follows :

1. The dynamic or spasmodic muscular contraction theory.
2. The mechanical theory.
3. The arrest of development theory.
4. The defect in the germ theory.

To dismiss the last-named theory first, it may be said at once that it hardly applies to ordinary cases of congenital talipes varus, in which there is merely alteration in the position or conformation of the bones but no absence of any bone or part of a bone or other evidence of any defect in the earliest condition of the germ. In those congenital deformities, however, in which there is absence of one of the bones of the leg, a deficiency in the number of the tarsal or metatarsal bones or of the toes, it is more than probable that the deformity is the result of some primitive germ-defect.

1. **The Dynamic or Spasmodic Muscular Contraction Theory.**— This theory, which has received the support of Mr. Little, Mr. Brodhurst, and Mr. Adams, amongst others, in this country, is perhaps the one that has been till quite recently most commonly held by orthopædic surgeons. The supporters of this theory contend that during early intra-uterine life, in consequence of some lesion, probably of a more or less temporary nature, of the cerebro-spinal nerve-centres, certain muscles are thrown into a state of tonic spasm or spasticity, and that as the result the bones are drawn into their abnormal position, where they become further fixed by the shortening of the ligaments, and subsequently moulded into their abnormal shape and arrested in their development. In favour of this view it is argued by Dr. Little* that (1) club-foot often co-exists with evident derangement of the nervous centres, as in acephalous, hemicephalous, and spina-bifidous subjects; (2) club-foot occasionally co-exists with an

* Holmes, 'System of Surgery,' vol. ii., p. 232.

analogous distortion of the upper extremity, clubbed hand, in which the muscles contracted are the anatomical homologues of the parts contracted in the lower limbs; (3) a comparison of club-foot with the distortions that occur after birth unmistakably from disease of the nervous system tends to prove that congenital and non-congenital club-foot spring from analogous causes. In furtherance of this view, Mr. Adams argues that it is possible that spasmodic muscular action may in the fœtus be induced by maternal influences, and he thinks this supposition is supported by the fact generally admitted, that violent convulsive movements of the child *in utero* may be induced by sudden and powerful emotion excited in the mind of the mother. Mental emotion, moreover, he says, in the large number of congenital cases is assigned by the mother as a cause. The defective nutrition which is sometimes observed in congenital club-foot, and which is said to be a condition favourable to spasmodic affections, is also brought forward as an argument, as is, too, the hereditary tendency which can sometimes be traced through successive generations, as in epilepsy and other nervous affections, and a tendency to relapse after operation and mechanical treatment. Dr. Little believes in severe cases relapse is often due to the spasmodic tendency remaining.

Against the dynamic or spasmodic muscular theory are the facts that no lesion, macroscopical or microscopical, has hitherto been discovered in the nervous centres or nerves supplying the contracted muscles. The muscles, beyond that they are shortened in a way similar to that in which all muscles have a tendency to become shortened when their points of attachment are approximated, present no change or evidence of any spasmodic affection. Messrs. Shattock and Parker, who have investigated microscopically the condition of the muscles, nerves and nerve-centres in club-foot, could discover no lesion; they found the parts apparently quite healthy. Moreover, after rectification of the deformity, the muscles 'act in perfect obedience to the will in every movement of the leg and foot, and this is the reverse of what occurs in non-congenital spasmodic cases, in which the muscles remain tense, hard, and prominent for many years after the seizure, frequently for the remainder

of life, and are only partially under the controlling influence of the will.' Often the mother can assign no cause, as mental emotion, and the infants are healthy and well nourished, showing no sign of defective nutrition. To the objection that no lesion of the nerve-centres or muscles is found, the supporters of the spasmodic theory reply that the 'affection is purely functional, or attended with such a slight organic lesion as under this condition of life is easily or completely recoverable.'*

2. **The Mechanical Theory.**—This theory is perhaps the oldest that has been advanced for the explanation of congenital club-foot. It received the support of Hippocrates and Galen, and was that held by Scarpa, Cruveilhier, Paré, Martin, and many others. In recent times it has again found favour, and is strongly supported by Volkmann, Vogt, Lücke, Kocher, Hoffa, Rédard, Shattock and Parker. This theory maintains that the deformity is the result of the foot being held mechanically in the deformed position, in which it becomes fixed by the contraction of the muscles and ligaments. The contraction of the muscles, therefore, which is regarded by the upholders of the dynamic theory as the cause of the deformity, is looked upon by those who advocate the mechanical view merely as the result. The alterations in the shape and articular surfaces of the bones are also considered as secondary, not as primary factors, as they are by those who hold the defective development view.

The mechanical forces that have been invoked as the cause of club-foot are pressure of the walls of the uterus, consequent upon its cavity being too small or too narrow for the fœtus; deficiency of liquor amnii; the presence of uterine tumours; twin pregnancies; and such conditions of the fœtus itself, as hydrocephalus, as would diminish the uterine space for the rest of its body.

Against the mechanical view it has been urged (1) that it is impossible that any pressure *in utero* could produce the deformity, since long after the formation of the limbs the infant is protected from the pressure of the uterine walls by the liquor amnii, and that the deformity has been met with as early as the third month;

* Adams, 'Club-foot,' p. 216 (1873).

(2) that where there has been deficient liquor amnii healthy infants have been born, whilst club-foot has existed where there has been excess of amniotic fluid; (3) that there is absence of deformity of parts which are retained in approximation during uterine life, as in the bent thigh, bent arm, stooping neck, flexed fingers, etc., all positions assumed by the fœtus in adaptation to the limited space it occupies. Mr. Adams also argues that pressure would be very unlikely to produce the extreme elevation of the os calcis, which often exists in severe cases of talipes varus.

On the other hand, there are abundant specimens in the various museums, both in this country and on the Continent, which show almost conclusively that the foot may be mechanically locked or fixed in the deformed position through abnormal position of the limbs, adhesion of the amnion, and other conditions.

Moreover, the observations of Volkmann and Lücke demonstrate that in some cases of talipes the foot has been subjected to pressure. Volkmann, and subsequently Lücke, pointed out that over the external malleolus and prominent points of bone of the tarsus there frequently exist atrophic areas of skin with sometimes adventitious bursæ beneath them, which could clearly only be produced by pressure or rubbing. These areas are sharply circumscribed, almost circular in shape, and of about the size of a lentil. They are covered with a thin layer of epidermic cells, and present no trace of papillæ, sweat-ducts, or sebaceous glands. The rete Malpighii is reduced to a very fine line, and the fat beneath is deficient, appearing as if it had been cleanly punched out. But these atrophic areas are found not only over parts of the foot that are in contact with the uterine walls, but also over other parts of the fœtus that touch each other and are thus subjected to pressure.* Thus they are found on the inner surface of the legs, the heads of the metatarsal bones, and the inner borders of the soles of the feet.

Another point in favour of the mechanical theory is the fact

* Pittha and Billroth, 'Handbuch der Chir.,' vol. ii., p. 690; Lücke, 'Ueber den augebornen Klumpfuss.' Klinische Vorträge, No. 16.

that after birth long-continued abnormal positions are followed by contraction and shortening of the muscles and ligaments, with fixation of the foot in similar positions to those met with congenitally.

'It must not be supposed,' says Mr. Parker,* 'when invoking environment, that some great mechanical power is referred to. If the extreme delicacy of the growing fœtus be remembered, and the nature of the majority of the deformities—a more or less exaggerated condition of a sometime physiological type—it will be conceded that but little pressure is needed. And that the uterus may and does exercise pressure on the fœtus within it, there are numberless examples other than club-feet to show.'

According to some recent upholders of the mechanical theory, amongst whom Mr. Parker takes a prominent place, club-foot is the result either (1) of retention of the foot for too long a time in what at one period of gestation was its normal physiological position; or (2) of fixation of the foot in the talipedic position, consequent upon the abnormal position of the limbs or the interlocking of the feet.

These conditions may be discussed separately:

1. *Retention of the Foot for too long a Time in what at one Period of Intra-uterine Gestation was the Normal Position.*—It is now a well-known physiological fact that the foot assumes various positions *in utero* in the course of development. 'This,' says Mr. Parker, 'is doubtlessly ordained in order that the muscles, joint-surfaces, and the ligaments, shall be so developed as to allow of that variety of movement and position which are afterwards to be natural to the foot. Should anything prevent the movement of the feet at the proper time, or maintain them in any given position beyond the limit of time during which they should usually occupy such position, talipes results. The severity of the deformity will be in direct ratio to the violence at work; the variety of the deformity will depend on the period at which the violence commences to act. Club-foot,' he says, 'at birth is a deformity only because it is a permanent though sometimes exaggerated condition of a physiological position.'

* Parker, 'Congenital Club-foot,' 1887, p. 51.

After the third month, at which time the joints are formed, the fœtus is placed in the uterus with the legs crossed, the thigh being strongly turned outwards and flexed on the pelvis; the leg is partially flexed on the thigh, its internal surface touching the abdomen; the feet, with their soles applied to the abdominal walls, are adducted and plantar-flexed—that is, in the position of varus. At a later period a gradual inward rotation of the lower limb occurs, in consequence of which the extensor surface of the flexed thigh is brought into contact with the body; whilst the internal surfaces of the flexed legs are turned towards each other. The soles of the feet, which are now applied against the uterine walls, are dorsal-flexed as well as rotated outwards—that is, in the position of talipes calcaneus. Any condition retaining the foot in the first position of plantar flexion and inversion will lead to varus; any condition retaining the foot in the later position, that of dorsal flexion and eversion, will lead to calcaneus.

Many specimens in the various museums both here and on the Continent appear to support this view. According to Mr. Parker, varus is more frequent than calcaneus, because the conditions producing the former act at an earlier period and are longer maintained. Hence also the more intractable nature of the deformity. Berg* points out as additional evidence that in congenital varus the limb is in a position of outward rotation.

It now remains to be shown what are the conditions that may prevent the normal rotation of the limb and fix the foot in the position of plantar flexion and inversion for so long a period that the position becomes permanent in consequence of the contraction and shortening of the ligaments and muscles. As these conditions, however, appear to be similar to those acting under our second head, this may be considered before they are discussed.

2. *Fixation of the Foot in the Deformed Position consequent upon Abnormal Position of the Limbs, or the Interlocking of the Feet.*—There are numerous specimens which illustrate how an abnormal position of the limb may cause the foot to become locked.

* Berg, 'Séguin's Archives of Medicine,' vol. viii., No. 3, Dec., 1882.

Cruveilhier gives a case in which the right foot was fixed in the position of extreme equino-varus beneath the chin, the knees being extended and the legs flexed on the pelvis; Volkmann a case in which the feet were interlocked in the position of equino-varus on one side and calcaneus on the other; whilst in a specimen (No. 1,226) in St. Bartholomew's Hospital Museum, the thigh is flexed on the left side and the knee extended with the foot on the opposite cheek in a position of marked varus, the sole and heel being opposed to the wall of the uterus.

It is contended that the normal rotation of the foot may be interfered with, or the abnormal position and consequent locking and fixation of the foot may be brought about (*a*) by certain abnormal conditions in the environment of the fœtus, or (*b*) by abnormalities in the fœtus itself.

(*a*) *Abnormalities in the Environment.*—1. *A too small or too narrow uterus.* Compression of the fœtus in a too narrow uterus was believed to be a cause of club-foot by Scarpa, Henke, Chaussier and Palletta. It would appear also that compression may be exercised by the walls of the cyst in extra-uterine pregnancies. In several cases of club-foot occurring in such there has been abundant evidence of compression on various parts of the fœtus.

2. *Deficiency of Liquor Amnii.*—Martin and Chaussier were strong advocates that a deficiency in the quantity of the liquor amnii was the cause of club-foot.

Martin, who adduced many examples from his own practice, contended that during certain periods of pregnancy there was a deficiency of the amniotic water, and that, consequently, the uterine walls pressed directly on the foot, and held it in the deformed position till it became fixed by the contraction of the muscles and ligaments. He asserted that in twin pregnancies club-feet were common, and said that this was so because the liquor amnii in such did not exceed in quantity that present in a single pregnancy.

Cruveilhier, however, showed that there is not always a deficiency of liquor amnii in cases of club-foot, and that in some instances where the fluid was deficient no club-foot had occurred.

It is clear, therefore, that such is not the only way in which pressure may be made upon the foot, but Cruveilhier's observations do not prove that a deficiency of the amniotic water may not sometimes be the cause of the foot being too long retained in the abnormal position. Against the view of deficiency of liquor amnii, moreover, it has been argued that club-foot is sometimes hereditary on the male side; but this, as pointed out by Mr. Parker, has no special weight, in that the amniotic fluid is a product chiefly of the fœtus itself. An hereditary deficiency might therefore be handed down by either the father or the mother.

3. *Amniotic Bands; Adhesion of the Amnion to the Fœtus.*—Dureste endeavours to show that club-foot, as well as several other deformities, may be due to the compression of a too narrow amnion. Thus, he thinks that the amnion, instead of separating itself from the fœtus in the normal manner, remains in contact with it, so that the limbs are, as it were, tied down by it, and are hence unable to undergo their normal evolution. According to the situation and the time at which the compression is made, the limb may be completely or partially arrested in its development; or the evolution may proceed in the normal manner, but only at the expense of one segment of a limb remaining flexed upon another, as in club-hand, or club-foot.

Specimens of amniotic bands binding the limbs in various positions are present in the museums.

4. *Entanglement by the Umbilical Cord.*—In a few cases the foot has been found with the umbilical cord rolled round it so as to hold it in the deformed position.*

5. *Uterine Tumours.*—Uterine tumours, in that they may encroach upon the cubic space of the uterine cavity, may lead to compression of the foot or fixation of the limb in an abnormal position, or may prevent the rotation of the limb if in the normal position.

(*b*) *Abnormalities in the Fœtus itself.*—Certain morbid conditions of the fœtus—as hydrocephalus, abdominal tumours, etc. —in that they cause encroachment on the uterine space, may lead to club-foot either by interference with normal rotation or by causing malposition of the limbs.

* Parker, Little, *op. cit.*

Other morbid conditions of the fœtus, such as fœtal rickets, congenital paralysis, spina bifida, etc. — in short, any morbid state weakening the fœtus—may render it less resistant and unable to overcome such slight degrees of compression from its environment, as in a healthier fœtus would be impotent to take effect.

3. **Arrest of Development Theory**.—The supporters of this view hold that club-foot is due to an arrest of development of the lower limbs.

Berg and Wolff maintain, as do some of the modern upholders of the mechanical theory, that the deformity of the foot is due to the prevention of the normal inward rotation of the limb. This they regard as due to some inherent vice in the fœtus, and not as the result of mechanical causes acting on the fœtus from without.

Hueter* holds that the deformity is due to a defect in development chiefly in the astragalus, the neck of this bone retaining the obliquity of an earlier period instead of assuming the later fœtal form. The alterations in the position of the bones are, on this view, looked upon as consequences of the malformation of the astragalus, and the contraction of the muscles and ligaments is regarded, as in the mechanical theory, as due to passive shortening and the approximation of their attachments. Careful inspection of the astragalus in club-foot, however, would appear to show that at one time in fœtal life the bones that articulate with it held their normal relations to it, inasmuch as there are evidences of the remains of normal articular surfaces, as well as of the formation of new ones corresponding to the shifted position of the bones. Thus there generally exists a redundant portion of articular surface on the head of the astragalus to the outer side of the scaphoid bone, corresponding to the position of the scaphoid in the normal condition. A similar redundancy is observable also on the anterior portion of the trochlear surface of the astragalus, corresponding to the position which would be occupied by the tibia if the foot were not in an abnormal position of extension. From these appearances it is argued that the displacement of the

* 'Archiv für klin. Chirurgie,' vol. iv., part i., p. 125; 'Virchow's Archiv,' vol. xxv., p. 598.

foot has occurred at a period subsequent to the development of an astragalus of normal conformation.

Such are some of the arguments for and agaïnst the various theories; and although it cannot be said that any one of these theories is capable of being proved, we venture to think that the mechanical is, on the whole, the most tenable. We would especially direct the attention of those interested in the question to the able essay of Mr. Parker, and to the work published by him conjointly with Mr. Shattock in the Transactions of the Pathological Society.

CHAPTER IV.

## PATHOLOGICAL ANATOMY OF CONGENITAL TALIPES VARUS.

The account here given of the pathological anatomy of club-foot is founded chiefly on specimens in St. Bartholomew's Hospital Museum, and on dissections made by the authors. In writing their description, however, they have availed themselves of the work done in the same direction by others.

The first important description of the anatomy of club-foot was given by Scarpa,* in 1803. Since then many valuable accounts of the deformity have been published by Adams, Shattock, Parker, Bessel-Hagen, Scudder, Hoffa, Rédard, and others, and dissections have been placed in the various museums.

Perhaps the most striking characteristic of a dissected specimen is the general rounded, shortened, and twisted appearance of the foot. The inner border is shortened and concave, the outer border unnaturally convex; the dorsal surface looks forwards and downwards, the plantar backwards and upwards; the os calcis is drawn upwards by the tendo Achillis; the astragalus is tilted forwards partially out of its socket; and the bones in front of the transverse tarsal joint are adducted and rotated, so that the tubercle of the scaphoid is drawn upwards and inwards towards the internal malleolus (Fig. 52).

On examining a number of specimens, it will be at once obvious that there are marked differences in the condition of the bones and articulations as found in the infant at birth and child who has not yet walked on the foot, and as found in the child who has walked and in the adult. We shall follow former authors, therefore, in describing these conditions separately.

* 'A Memoir on Congenital Club-foot in Children, and on the Mode of Correcting that Deformity,' by Antonio Scarpa. Translated from the Italian by J. H. Wishart; Edinburgh, 1818.

## I. The Anatomy of Club-foot in the Infant at Birth, and in the Child before it has walked on the Deformed Foot.

It has been affirmed by some surgeons that there are no alterations in the bones and articular surfaces in a club-foot of an infant at birth, and that the conditions that have been described are the result of pressure in walking on the foot. Such, however, is not in accord with the observations of most surgeons, nor

Fig. 52.—Photograph of a Specimen of Congenital Talipes Varus. (No. 3,510, St. Bartholomew's Hospital Museum.)

with our own. In dissections that have been made by ourselves and others, there have been found not only alterations in the articular surfaces and in the relations of the bones to each other, but also alterations in the conformation of the bones themselves.

The altered relation in the position of the bones occurs chiefly at the ankle and at the transverse tarsal and the subastragaloid joints. Thus, the astragalus is to a greater or less extent tilted forwards out of the socket formed for it by the tibia and fibula; the scaphoid and cuboid, with the bones in front of them, are adducted on the head of the astragalus and anterior end of the os

calcis, and the whole foot below the astragalus is adducted and rotated on the inferior surface of the astragalus. Besides the alterations in the position and shape of the bones, the ligaments on the inner side of the foot are shortened, those on the outer side elongated. The tendo Achillis and tibial tendons, and the

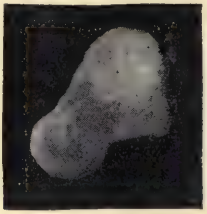

Fig. 53.—Photograph of an Astragalus from a Still-born Child the Subject of Talipes Varus (Left Side).

plantar fascia and muscles on the inner side of the sole, are contracted and tense. The alteration in the bones, the ligaments, and the muscles will next be considered in detail.

**The Bones.**—All the bones of the tarsus are perhaps generally smaller than normal, and have to a greater or less extent an inward inclination. The relations which the bones bear to each

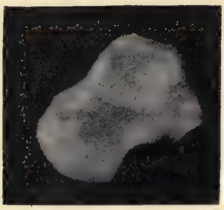

Fig. 54.—Photograph of an Astragalus of an Infant with Normal Foot (Left Side).

other as a whole have already been briefly mentioned, and will be considered more fully when the malformation of each individual bone has been described.

The chief alterations are in the *astragalus* and *os calcis*. The bones in front of the transverse tarsal joint, though displaced in a way to be presently mentioned, are but little, if at all, altered.

**The Astragalus.**—The most striking alteration in the astragalus lies in its small size, and in the abnormal obliquity of its neck. In the normal adult astragalus the long axis of the neck is directed forwards and slightly inwards and downwards. In the talipedic the long axis, as a rule, is directed still farther inwards and downwards, and the neck itself is often slightly elongated.

FIG. 55.—PHOTOGRAPH OF A NORMAL ASTRAGALUS FROM AN INFANT (RIGHT SIDE).

The articular surface of the head looks abnormally inwards, and often presents in place of the globular surface for the scaphoid two facets (Fig. 60), the inner, when the bones are in position, being for the scaphoid, whilst the outer is free and unopposed on the dorsum of the foot. We must now enter somewhat more minutely into details, and consider the various alterations that have been

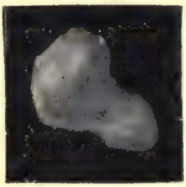

FIG. 56.—PHOTOGRAPH OF AN ASTRAGALUS OF A STILL-BORN CHILD THE SUBJECT OF MARKED VARUS (RIGHT SIDE).

**The lateral deviation of the neck of the bone is extreme.**

observed in the conformation of the bone under the following heads:

1. *The Size of the Bone.*—The small size of the bone is better appreciated where the deformity has been unilateral, in that the astragalus of the deformed foot can then be compared with the

astragalus of the healthy foot of the opposite side. In three cases dissected by Longuet* this diminution in size of the astragalus on the affected side was very marked.

2. *The Obliquity of the Neck.*—Especial attention was drawn to the obliquity of the neck by Mr. Adams,† and the subject has been since worked at by Mr. R. W. Parker,‡ who has compared the inward obliquity in the normal adult astragalus with that in the fœtal astragalus, the talipedic astragalus, and the astragalus in the Anthropomorpha. His method of measuring the obliquity is as follows: 'The astragalus, with its trochlear surface upwards and horizontal, was placed beneath a fine thread fixed across it; a second thread was fixed at right angles to this along the mid-

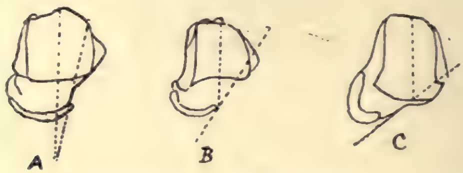


Fig. 57.—Method of measuring the Inward Obliquity of the Neck of the Astragalus. (After Parker.)

A, Normal adult; B, normal fœtal; C, talipedic infant.

line of the trochlear surface, parallel with its inner border; whilst a third was placed along the outer margin of the neck of the bone, so as to intersect the other two; the angle formed by the meeting of the two threads last described was taken as the measure of the obliquity of the neck. The subjoined woodcut, from which, however, the transverse lines have been omitted, will explain this. In this manner the obliquity of the neck in twenty specimens of adult astragali taken promiscuously was measured. The mean angle was found to be 10·65°, the maximum was 26°; in three cases the angle was so small that to measure it was impracticable. In two cases only the angle amounted to 20° and upwards; in twelve cases it did not exceed 12°, and in the majority was under

* 'Revue d'Orthopédie,' May, 1892, p. 218. In three cases Longuet dissected he was particularly struck with the want of development and delay of ossification. The astragalus was half the size of that of the opposite foot. The inward obliquity of the neck was 105°, 110°, and 125° respectively.

† Adams, 'Club-foot,' p. 135; 1866.

‡ Parker, 'Club-foot,' p. 15.

10°. In the fœtus, from about the fourth month up to term, the mean angle in eleven cases was 38°, the maximum 42°, and the minimum 35°. In three cases only did the angle exceed 40°. In two cases of calcaneus this obliquity amounted to 33° and 39° respectively, the average being 36°. In five cases of equino-varus (varus) the mean angle was 49·6°, the maximum 64°, the minimum 31°, the average being 49·6°.'

Scudder, taking the average of his own measurements added to those of Parker and Shattock, fixes the angle of obliquity at 12·32° in the adult, at 35·75° in the fœtus, and at 50·05° in the talipedic case. In one case dissected by Mr. Parker the obliquity of the neck was found to be less than the mean of the normal

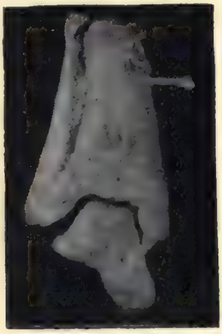

Fig. 58.—Photograph of a Portion of a Fœtal Leg, showing Inward Inclination of Neck of Astragalus in Congenital Varus. (St. Bartholomew's Hospital Museum.)

fœtal astragalus, namely, 31° *versus* 38°. In all the specimens we have dissected we have found the inward obliquity of the neck well marked, and exceeding that of the normal fœtal astragalus, and the same may be said of the astragali that we have removed from older children with confirmed and intractable phases of the deformity. Moreover, in some normal fœtal astragali we have found the angle of obliquity has not exceeded that of the adult bone.

But over and above the inward deflection of the astragaloid neck there is often a downward inclination (Fig. 61). This in some specimens we have examined has been very marked. It is referred to later in the description of the bone in children who have walked and in adults.

3. *The Length of the Neck.*—The neck appears often increased in length. Mr. Adams, however, thinks the increase in length is only apparent, and is dependent upon the altered relations and imperfect development of the articular surfaces of the head, rather than upon any real increase of length in the bone itself. In some cases we have examined there has been an undoubted increase in length, independent, it seemed to us, of any alteration that also existed in the articular surfaces. Hueter describes the neck as elongated on its outer side, and Rédard as replaced by a mammillated tubercle on which the articular surface for the scaphoid is seen.

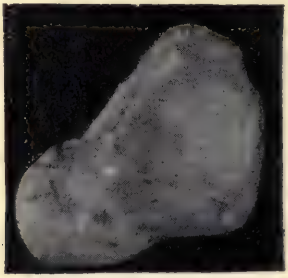

FIG. 59.—PHOTOGRAPH OF AN ASTRAGALUS FROM A CHILD WITH CONGENITAL VARUS, SHOWING INWARD INCLINATION OF NECK OF ASTRAGALUS. (No. 3509*c*, St. Bartholomew's Hospital Museum.)

4. *The Head of the Bone.*—The convex articular surface of the head, which corresponds with the concave socket of the scaphoid, instead of looking forwards and slightly inwards and downwards as in the adult bone, looks as a rule, in the talipedic astragalus, almost directly inwards with a distinct, and sometimes a considerable inclination downwards. It is frequently divided by a ridge into two facets, instead of presenting a single facet as in the normal bone. The inner facet is in contact with the scaphoid, which is drawn round in a direction inwards, backwards, and upwards, so as to come in contact in severe cases with the internal malleolus, whilst the outer facet is unopposed by bone, and can be felt projecting on the outer part of the dorsum of the foot as a distinct rounded prominence. This outer facet has been found devoid of the polish characterizing normal articular surfaces, and covered with a thin layer of connective tissue. The internal of

the two facets on the head of the bone has been spoken of as prolonged on the inner surface of the neck. It seems doubtful to the authors if this is always the case, but rather that the apparent prolongation is due to the scaphoid encroaching upon the smooth cartilaginous-covered surface of the head, which is normally in contact with the upper and inner synovial surfaces of the inferior and internal calcaneo-scaphoid ligaments respectively. This surface often forms a distinct facet, separated from the normal articular surface for the scaphoid by a distinct ridge. In some of the astragali we have examined this ridge has disappeared, and a continuous smooth facet extended backwards to the rough surface for the deltoid ligament.

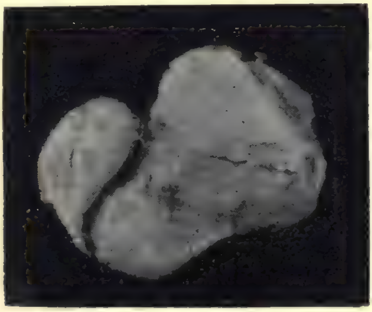

FIG. 60.—PHOTOGRAPH OF AN ASTRAGALUS AND SCAPHOID FROM A CHILD WITH CONGENITAL VARUS.

The displacement of the scaphoid on the astragalus is well illustrated. The exposed portion of the articular surface of the head of the astragalus has lost its smooth cartilaginous appearance.

In one specimen we found the articular surfaces on the head met at a distinct angle, so that the surface which articulated with the scaphoid looked directly inwards, and the other surface almost directly forwards with a slight inclination outwards.

5. *The Superior Articular Surface.*—In the astragali we have examined this surface has not shown much alteration. In consequence of the more or less extruded position in which the bone is placed, the superior surface is at times prolonged backwards, and in some specimens is continuous with the posterior inferior facet, the posterior border of the bone being thinned out and reduced

to a sharp edge between the superior and posterior inferior articular surfaces. The anterior third or fourth of the trochlear surface, which is extruded from the ankle-joint, has been found separated by a distinct ridge from the posterior two-thirds, and 'impressed by the fasciculi of the anterior ligament'* of the ankle. The portion in contact with the tibia has been observed somewhat flattened or less convex than normal. In one specimen of severe varus we dissected, the superior surface, though about one-third was tilted out of the ankle-joint, appeared in all respects normal, except that it was prolonged up to the posterior edge of the bone.

6. *The Internal Articular Surface.*—This surface appears to be always greatly diminished in size, and often reduced to little more

Fig. 61.—Outer View of Fœtal Astragalus, showing Declination of Head and Neck downwards in Varus.

than a smooth, narrow, articular ridge along the upper edge of the inner surface of the bone. The greater part of the inner surface is occupied by the deltoid ligament, which seems to have taken the place of the normal pear-shaped articular surface. In a specimen examined by Mr. Parker the internal malleolar facet was unrecognisable. In a specimen of our own the internal facet was prolonged quite to the scaphoidal facet on the head, and, indeed, appeared to be continuous with it. In the fœtus this facet normally extends on the inner side and upper surface of the neck somewhat further than in the adult bone, the greater part of the broader end of the pear-shaped inner facet being on the neck. Since this portion is to a greater or less extent extruded from the ankle-joint, it would appear that obliteration of this part takes place, and that the narrow ledge which, in varus, alone

* Parker, 'Club-foot.'

represents the inner facet, is the narrow posterior stalk-like portion of the normal inner facet.

7. *The External Surface.*—The external articular facet on this surface is usually well developed, and at times, in consequence of the anterior portion being partially extruded from the ankle-joint, appears to be prolonged backwards and larger than normal. In a specimen of our own this facet is divided by a distinct vertical ridge into two portions, an anterior, convex from before backwards, and a posterior concave. The anterior portion appeared to lie in front of the external malleolus, the posterior to articulate with the facet on that bone.

8. *The Inferior Surface.*—On this surface the posterior articular facet is somewhat shortened in its long axis. The long axis of the facet, which in the normal bone is directed obliquely forwards and outwards, in the talipedic runs almost directly forwards with a very slight outward inclination. The plane of this surface is downwards, backwards, and outwards, instead of being almost directly downwards as in the normal bone. The anterior inferior facet, which is situated on the inner part of the lower aspect of the neck, is, with respect to the posterior inferior facet, placed more inwards than normal, in some specimens being altogether internal to the posterior facet. Its long axis is directed antero-posteriorly. Its plane looks backwards and downwards, or where the neck is inclined more downwards than usual, directly backwards. In the specimens we have examined it has been found in some flat, in others slightly concave, in others very slightly convex. In some, in place of being partly on the lower surface of the head of the bone, it was altogether behind the head.

**The Os Calcis.** — This bone, like the astragalus, appears abnormally small, being especially ill developed in its posterior half. It lies rotated on its long axis inwards and downwards beneath the astragalus, so that its posterior end is nearer to the external malleolus than normal. It is also abnormally curved in its long axis, its outer surface being slightly convex, its inner surface unnaturally concave; whilst its cubcidal articular facet, in place of looking almost directly forwards as in the normal bone, looks forwards, inwards, and downwards.

1. *The Tuberosity* is drawn upwards, so that in severe cases

it lies above the level of the articular surface of the lower end of the tibia. It is smaller than normal, and when looked at posteriorly presents a distinct twist, the outer margin of the posterior surface being convex, the inner margin being still more concave. The tendo Achillis is attached more to the inner side of the posterior surface than normal.

Fig. 62.—Photograph of an Os Calcis from a Fœtus the Subject of Congenital Varus.

This bone was enlarged in the process of being photographed.

2. *The Superior Surface.*—The posterior superior articular facet is convex, and extends on to the concave inner surface of the bone. With the bone held in the position of talipes varus this facet looks forwards and inwards, its long axis is directed forwards

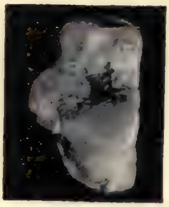

Fig. 63.—Photograph of a Normal Os Calcis from an Infant.

and inwards, and it is convex from side to side. The facet has been found partially uncovered on its outer side, and separated from the rest of the articular surface by a distinct ridge. The outer part of this facet may be in contact with the posterior border of the external malleolus. In a specimen of our own the

external surface of this facet was in contact with the external malleolus, a distinct synovial joint being situated between them. The anterior facet on the sustentaculum tali is slightly more internal than natural, and may be flat or slightly concave, or even slightly convex. With the bone in the position of talipes it looks forwards and upwards, or almost directly forwards, according to the degree of elevation of the tuberosity of the os calcis.

3. *The Inferior Surface* is concave from before backwards. The internal tuberosity is directed unnaturally inwards; the external tuberosity is but poorly marked. The anterior third of this surface is directed inwards as well as forwards; the depression for the calcaneo-cuboid ligament is transferred, as it were, more from this surface to the internal surface of the bone. Crossing the end of the bone in the situation of the calcaneo-cuboid depression is a deep and wide groove for the peroneus longus, extending from the outer surface over the anterior end of the lower surface.

4. *The External Surface* is unnaturally convex, and presents two distinct grooves, one for the peroneus brevis above, and one much wider and deeper below for the peroneus longus. The latter groove, as already stated, is continued on to the anterior third of the lower surface of the bone. At the upper part of the external surface there is often a distinct articular facet for the external malleolus, almost continuous with the posterior external facet.

5. *The Internal Surface.*—This surface is abnormally concave both from before backwards and from above downwards. The internal or greater of the posterior tuberosities projects on this surface, and the depression for the short calcaneo-cuboid ligament is almost altogether transferred from the lower surface of the bone to this surface.

6. *The Anterior Surface.*—The anterior articular facet for the cuboid looks inwards, downwards and forwards, instead of almost directly forwards, as in the normal bone. This alteration in direction would appear to depend in part upon the articular surface being, as it were, shifted inwards on to the inner surface of the bone, and in part upon the anterior end of the os calcis being bent inwards. Immediately behind the upper and outer

part of the cuboidal facet the bone presents a kind of tuberosity, due apparently to an overgrowth in that situation of the cartilaginous basis of the bone. In the normal bone the inner half of the anterior facet is somewhat convex from side to side, and looks a little inwards as well as forwards, whilst above and externally the surface often ends in a more or less distinct tubercle or ridge. In the talipedic bone the whole of the anterior articular surface takes the slope of the normal inner part, and the above-mentioned tubercle or ridge is greatly accentuated.

7. *The Sustentaculum Tali* is rather less well marked and prominent than in the normal bone.

**The Scaphoid.**—This bone is not much altered in shape, but we have noticed the tuberosity somewhat enlarged, and on it in severe cases have found an articular facet for the internal malleolus.

**The Cuboid.**—This bone, like the scaphoid, is very little if at all altered in shape. The calcanean facet, however, we have noticed presenting a smooth, slightly convex, head-like surface, instead of the normal nearly flat or concavo-convex surface. This facet, moreover, may be prolonged externally beyond the corresponding articular facet on the os calcis, being then partially unopposed by bone and in contact with the tendon of the peroneus brevis. In consequence of the elevation of the tuberosity of the os calcis, and the inward bend of the anterior end of that bone, this surface, in place of looking nearly directly backwards, looks backwards, outwards, and upwards. The anterior facets for the fourth and fifth metatarsal bones look forwards, inwards, and downwards, instead of forwards, outwards and slightly downwards. The dorsal surface looks almost directly outwards, instead of outwards and upwards. The plantar surface looks inwards; the groove on it for the peroneus longus is less well marked than normal.

**The Cuneiform Bones** present nothing remarkable with regard to their shape. They are, perhaps, slightly compressed on their inner sides, and the facets for the metatarsal bones look more outwards than normal. On the internal cuneiform bone a facet for articulation with the internal malleolus has been observed.

**The Metatarsal Bones.**—All the metatarsal bones incline inwards. The end-facets on the bases are more oblique, and look more inwards than in the normal foot.

**The Phalanges.**—These bones present no special alteration in shape in the infant.

**The Bones of the Leg.**—The tibia has been described* as having undergone a torsion or twist in the lower half of its diaphysis, so that the anterior surface of its lower articular end looks outwards, the internal malleolus being placed in front of the external. This would certainly not appear to be the common condition. Usually, the rotation would appear to be inwards, so that the external malleolus is on a more anterior plane than the internal, and the long axis of the tibio-fibular socket is directed forwards and inwards instead of forwards. The malleoli, according to Mr. Adams, are never altered in their relative position or size. The apparent anterior position and small size of the internal malleolus he attributes to the proximity of the scaphoid, causing it to become obscured. On dissection he has always found it of natural size. The forward projection of the internal malleolus, which has been described by some authors, and attributed to an outward rotation of the lower end of the tibia, is more apparent than real, and due, it would seem, to the obliquity of the os calcis, the tuberosity of which is drawn into contact with the external malleolus, so that when the foot is held with the long axis of the os calcis antero-posteriorly, the internal malleolus, in consequence of the foot being thus wheeled round, appears in front of the external. In a case dissected by Mr. Parker, there was found an actual rotation inwards of the lower half of the tibia, so that the external malleolus was actually on a plane anterior to the internal. This condition has also been noted by Dubrueil and others, and is the condition we have ourselves found.

**The Altered Relations of the Bones.**—Having described in detail the alterations in the shape of the bones and their articular facets, we may now enter upon the alterations in the relations which they bear to each other.

It has already been mentioned in passing that the foot is plantar-flexed, or extended at the ankle-joint, that the anterior part of the foot is adducted at the transverse tarsal joint, and that

* Scarpa and Rédard.

the whole of the foot below the astragalus is adducted, and rotated inwards at the subastragaloid joint. We have now to consider these displacements more in detail.

1. *The Relation of the Astragalus to the Bones of the Leg.*—The astragalus is more or less, according to the severity of the case, tilted out of its socket, so that one-third or more of its superior articular surface is exposed on the dorsum of the foot. There is some discrepancy amongst authors as to whether there is also any rotation of the bone or lateral displacement. Mr. Adams* says he has not detected lateral inclination or rotation inwards in any case, but, contrary to what might be expected, has observed in every instance that the body of this bone, or that portion which normally enters into the composition of the ankle-joint, is to a greater or less extent rotated outwards. By others it is said to be rotated inwards. In our preliminary chapter on the movements of the foot we pointed out how, in consequence of the greater convexity of the outer border of the superior articular surface of the astragalus and the direction of the trochlear surface itself as a whole, the astragalus and the foot in extension or plantar-flexion inclines inwards as well as forwards and downwards. Now, the astragalus in talipes varus being in a state of plantar flexion, it necessarily follows that the head inclines inwards as well as downwards. Hence we find that the external malleolar facet is drawn somewhat forwards in front of the external malleolus, whilst the upper and inner surface of the neck is in contact with the anterior border of the internal malleolus. Briefly, therefore, we consider that the astragalus is plantar-flexed, and rotated inwards at the ankle-joint.

2. *The Relation of the Astragalus to the Scaphoid and Os Calcis.*—The scaphoid is displaced inwards, leaving the outer portion of the globular convex surface of the head of the astragalus unopposed. The os calcis is also rotated beneath the astragalus in such a manner that whilst the tuberosity is carried outwards towards the fibula, its anterior end is carried inwards, so that it lies almost vertically beneath the head of the astragalus, instead of to a great extent external to it, as in the normal condition of the parts. The os calcis, however, is not only rotated as above described, but is also rolled on its long axis in such a

* Adams, 'Club-foot.'

manner that its plantar surface looks inwards as well as downwards, and its internal surface somewhat upwards as well as inwards. Hence the superior posterior or external articular facet appears more convex than normal, and is prolonged to some extent on the inner surface of the bone. The change in position, then, of the scaphoid and os calcis on the astragalus we would describe as occurring chiefly at the subastragaloid rather than at the transverse tarsal joint. We do not mean to say that there is no shifting at this articulation. The alteration in the direction of the anterior facet on the os calcis is sufficient to show this. What we maintain is, rather, that the astragalus, with the rest of the bones, having followed the elevation of the heel, and having consequently been thrown into a state of plantar flexion, the remainder of the tarsal bones, in one piece as it were, are adducted, and at the same time rotated inwards at the subastragaloid joint.* The fulcrum on which the bones beneath the astragalus roll is the interosseous ligament.

3. *The Relation of the Os Calcis to the Cuboid.*—The cuboid, instead of being almost in a line with the long axis of the os calcis, articulates with it, in consequence of the inward inclination of the anterior facet, at an angle. In the specimens we have examined the articulation between the os calcis and the cuboid practically forms a ball-and-socket joint, the facet on the cuboid being convex, and resembling to some extent the globular head of the astragalus; whilst the facet on the os calcis is slightly hollowed out and concave. The movement of the cuboid on the os calcis is in the direction of adduction.

The view we take, then, of the deformity is that, in the first place, the foot is plantar-flexed and adducted at the ankle-joint in a direction downwards and slightly inwards, but only within the normal range of movement; secondly, that the os calcis, with the scaphoid and the remaining bones of the tarsus, are together adducted and rotated inwards at the subastragaloid joint, but here, again, only within the normal physiological limits. Now, as the result of the force, whatever this may be, determining the plantar flexion, adduction, and rotation, the bones in front of the trans-

* The subastragaloid joint is that formed by the articulation of the two facets on the inferior surface and globular head of the astragalus above and behind with the two facets on the os calcis below, with the scaphoid in front, and with the calcaneo-scaphoid ligaments between the os calcis and scaphoid.

verse tarsal joint are still further adducted and rotated; whilst the soft cartilaginous neck of the astragalus and anterior end of the os calcis yield to the pressure, and are deflected more or less inwards and downwards as already described.

**The Ligaments.**—Briefly put, the dorsal or anterior ligaments and the ligaments on the outer side of the foot are stretched and elongated; the ligaments on the inner side of the foot and the posterior ligament of the ankle are shortened and contracted. The internal lateral ligament, together with the internal calcaneo-scaphoid, are more or less blended, and have been called collectively, by Mr. Parker, the astragalo-scaphoid capsule (Fig. 3, p. 4). It is these ligaments that hold, to a great extent, the scaphoid in its abnormal position. On the division of this mass of ligaments, the scaphoid can be drawn back into its normal situation, but at the same time an interval is left, when the bones are thus drawn into position, between the astragalus and scaphoid. The posterior ligament of the ankle, *i.e.*, the thickened ligamentous bands stretching between the posterior tibio-fibular ligament and the astragalus and os calcis, is said by Bessel Hagen and Parker to hold the os calcis in its position of plantar flexion. When these bands are divided, it is found in some cases that the foot can be brought up to a right angle, but then only, as a rule, at the expense of the separation of the articular surfaces of the tibia and astragalus.

*The plantar fascia* or *long plantar ligament* is shortened especially the internal lateral portion. It is not, however, always easy to be felt in the fat foot of the infant.

**The Muscles and Tendons.**—The muscles, both macroscopically and microscopically, have been found as a rule in a perfectly normal condition. The tendons, however, in severe cases are considerably displaced. In a few cases some diminution in size, or defective striation, has been noticed in the contracted muscles, and in a few instances hypertrophy of certain muscles, or parts of muscles, and atrophy or fatty degeneration of other muscles or other parts have been discovered. Detailed accounts of such are given by Mr. Adams in the Transactions of the Pathological Society.* In some of these cases, where the muscles have been found fatty, there have existed other defects, as spina bifida, mal-

* Adams, Transactions Pathological Society, vol. iii.

formation or congenital contraction of the hips and knees, etc. In the case of spina bifida, which is at times associated with paralysis of the lower limbs, the atrophy and fatty degeneration of the muscles would be explicable on the assumption of some lesion in the cord. In the patient from whom Fig. 63 was taken, there was not only complete muscular paralysis, but also anæsthesia of the lower limbs. In other cases, however, no lesion of the cord or nerves has been found to account for the unusual muscular condition. 'The existence of these muscular imperfections,' says Mr. Adams, 'when present to any marked extent, may be diagnosed by the total absence of the power of extending the toes or the foot, and the toes are drawn downwards and flexed towards the sole of the foot, as in paralytic cases.' Although Mr. Adams says he has been unable to discover any abnormal condition of the nerve-centres or nerve-trunks, he admits that further observations are necessary. Seeing that in the great majority of cases the muscles are perfectly healthy, we cannot help thinking that, when structural alterations exist, they are the result of some accidental nervous or muscular lesion, and quite independent of the deformity. The recognition that such conditions may be met with is of importance, since where they exist a complete restoration of the foot can hardly be hoped for. We shall refer again to these abnormal conditions under the head of prognosis.

The alteration in the direction of the tendons will now be given in detail:

1. *The tibialis anticus* is displaced inwards, and can generally be distinguished as a tense cord crossing over the internal malleolus to its insertion into the internal cuneiform and base of the first metatarsal bone. In very severe cases the tendon, after it has passed under the anterior annular ligament, turns slightly backwards to reach its insertion (Adams).

2. *The tibialis posticus* is displaced somewhat forwards, and passes from its groove behind the internal malleolus, directly downwards into the tuberosity of the scaphoid, which in severe cases is drawn upwards and inwards into contact with the malleolus. In the normal foot it will be remembered that the tendon, after leaving the groove behind the malleolus, passes obliquely downwards, forwards, and inwards over the internal lateral

ligament and inferior calcaneo-scaphoid ligament to its insertion into the tuberosity of the scaphoid. The relations of this muscle are again referred to in the section on Tenotomy, p. 184.

3. *The tendo Achillis* is shorter, and in consequence of the rotation of the os calcis is situated nearer to the fibula than in the normal condition of the parts. It is stated by M. Rédard and others to lie over the line of the posterior tibial artery. We agree, however, with Mr. Adams that it is really more external to the artery than in the normal foot.

4. *The peronei tendons*, on leaving the back of the external malleolus, cross the outer surface of the os calcis in a more downward direction than usual and very distinctly groove that bone. The peroneus longus winds round the inferior surface of the os calcis, occupying the situation of the deep pit at the anterior end of the bone for the short calcaneo-cuboid ligament, which is transferred, in correspondence with the displacement of the cuboid inwards, altogether on to the inner surface of the os calcis. On leaving the os calcis the tendon is said not to groove the cuboid at all, but to pass directly across the foot to its insertion. In a specimen in our possession, although it turned round the under surface of the os calcis in the way here described, it also grooved the front of the cuboid in the usual situation. In this specimen the deformity, though severe, was not extreme.

5. *The relations of the other tendons passing from the leg to the foot* are not of much importance, and are therefore not described in detail. The anterior set following the tibialis anticus are all more or less displaced inwards, and being held in front of the internal malleolus by the anterior annular ligament, the leg portion of the tendons forms with the foot portion a re-entering angle directed upwards and inwards.

The flexor tendons follow the course of the posterior tibial tendon behind the internal malleolus, and then run through the sole of the foot to their insertion. The groove on the astragalus being obliterated, the flexor longus hallucis passes at once beneath the sustentaculum tali across the sole of the foot to its insertion.

6. *The Muscles of the Sole.*—The muscles on the inner side of the sole are contracted and tense.

**The Vessels and Nerves**, beyond being shortened, are not much altered in their relations. The arteries are said by Guérin to be tortuous and to retain their normal length, an observation which has not been confirmed by others.

The posterior tibial artery is somewhat nearer the internal malleolus than normal.

No alteration in the structure of the nerves supplying the muscles, nor in that of the spinal cord, has been discovered, either by the naked eye or by the microscope.

**The Skin.**—Peculiar changes occur in the skin at spots where the foot has been subjected to pressure before birth. These are described in the section on Etiology, p. 71.

## II. The Pathological Anatomy of Congenital Varus in Children who have walked on the Deformed Foot and in Adults.

When the deformity is left untreated and the child has walked on the deformed foot, not only do the pathological conditions already described in the infant at birth and in the child who has not walked become confirmed, but further changes in the bones, ligaments and muscles ensue in consequence of the restricted movements of the foot and the weight of the body being transmitted abnormally through the tarsal and metatarsal bones. Thus, the bones become atrophied to some extent, and the abnormalities of the articular surfaces confirmed and increased; the articular surfaces not in contact lose their cartilage; the ligaments become permanently shortened, and the muscles more or less wasted from want of use. These changes will now be considered in detail under the heads of changes in the bones, ligaments and muscles.

**The Bones.**—In consequence of the restricted movements of the foot and the malnutrition of the whole limb, all the bones are somewhat smaller and lighter than normal, whilst their abnormal shape, as ossification proceeds, becomes permanent. Those parts of the bones, however, through which the weight is principally transmitted, namely, the head of the astragalus, the anterior end of the os calcis, the external part of the scaphoid, and the cuboid,*

* Adams, *op. cit.*, p. 165.

become thickened and irregularly enlarged. The abnormal articular surfaces become confirmed, and the normal articular surfaces left unopposed lose their cartilage, and acquire a non-articular character. Hence it is evident how important it is that treatment should be undertaken early, before the abnormalities in the shape of the bones and in their articular surfaces have become permanently established. The alteration in the relationship

FIG. 64.—PHOTOGRAPH OF A SPECIMEN OF SEVERE CONGENITAL VARUS IN THE ADULT (FRONT VIEW). (No. 3,510, St. Bartholomew's Hospital Museum.)

The tendons have unfortunately been allowed to become dry and displaced in the way seen in the photograph.

which the bones bear to each other will be considered after the alteration in shape of each individual bone has been described.

**The Astragalus.**—The chief alteration is found in the astragalus. In consequence of the elevation of the tuberosity of the os calcis, the astragalus assumes an almost vertical position, its trochlear surface being so tilted out of the socket formed for it by the bones of the leg that a little more than one-third in severe cases* remains in contact with the articular surface of the tibia.

* In the inveterate case (No. 3,510) in St. Bartholomew's Museum, a little less than half of the superior articular surface remains in contact with the lower

The remainder of the trochlear surface projects out of the joint, uncovered, except by soft tissues and the wasted anterior ligament, on the dorsum of the foot.

As in the infant, the conformation of the astragalus will be considered under the following heads:

1. *The Neck.*—The changes already noticed as occurring in the infant (p. 82) are exaggerated and confirmed. The inward, and

FIG. 65.—PHOTOGRAPH OF A SPECIMEN OF SEVERE CONGENITAL VARUS IN THE ADULT (FRONT VIEW). (No. 3,510, St. Bartholomew's Hospital Museum.)

This is taken from the same specimen as Fig. 64, but for the sake of clearness the tendons have been painted out of the negative, and the lines of the various articulations have been marked on the specimen with white paint.

especially the downward, deflection of the neck of the bone in the specimens we have examined is more marked and is greater than in the bone of the infant at birth. We call especial attention to the downward deflection of the neck, since this condition does not seem to have received from authors the attention it undoubtedly deserves. We regard this downward deflection of the astragaloid neck as one of the chief obstacles to the rectification

articular surface of the tibia; the rest of the articular surface, denuded of its cartilage, and rough and uneven, appears scored vertically by the fasciculi of the anterior ligament of the ankle-joint.

of the equinus position of the foot. We have found in the dissected specimen that after the superior surface of the astra-

FIG. 66.—PHOTOGRAPH OF A SPECIMEN OF SEVERE CONGENITAL VARUS IN THE ADULT, WITH SOFT PARTS REMOVED (INTERNAL VIEW). (From No. 3,510, St. Bartholomew's Hospital Museum.)

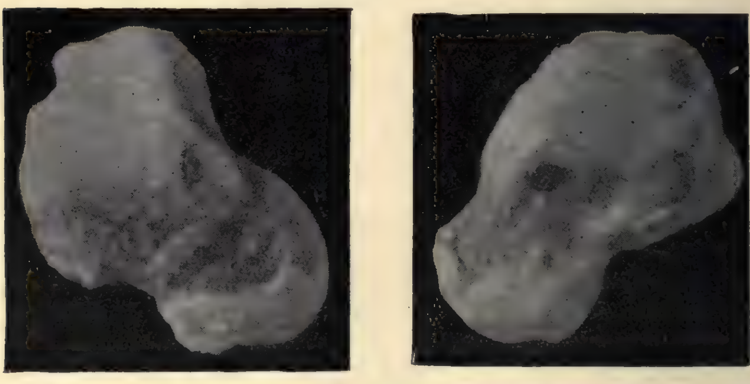

FIG. 67.—PHOTOGRAPH OF TWO ASTRAGALI FROM CASES OF RELAPSED CONGENITAL VARUS, SHOWING THE INWARD DEVIATION OF THE NECK.

galus has been replaced in its socket, the equinus position of the foot may still be maintained, in consequence of the down-

ward deflection of the neck preventing the bones in front of the astragalus being brought sufficiently upwards. The foot, in fact, is not only plantar-flexed at the ankle-joint, but is also further

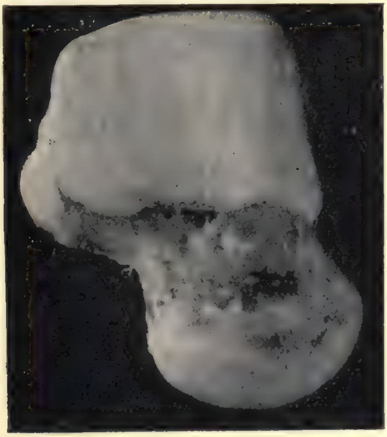

FIG. 68.—PHOTOGRAPH OF NORMAL ASTRAGALUS FROM A CHILD OF TEN YEARS OF AGE.

This bone was enlarged in the process of being photographed.

plantar-flexed at the transverse tarsal joint. The division of the tendo Achillis and posterior ligaments of the ankle-joint may

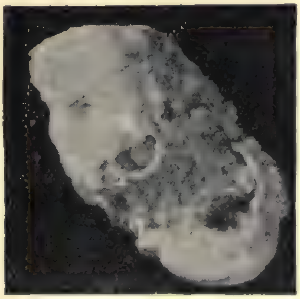

FIG. 69.—PHOTOGRAPH OF AN ASTRAGALUS REMOVED FROM AN INTRACTABLE CASE OF CONGENITAL TALIPES VARUS IN A CHILD OF SIX YEARS OF AGE AT ST. BARTHOLOMEW'S HOSPITAL.

suffice to allow of the extruded trochlear surface of the astragalus being replaced in the socket formed for it by the bones of the leg; but this is not enough to overcome the equinus. The downward

FIG. 70.—PHOTOGRAPH OF A NORMAL ASTRAGALUS FROM A CHILD AGED THREE YEARS.

The bone was enlarged in the process of being photographed.

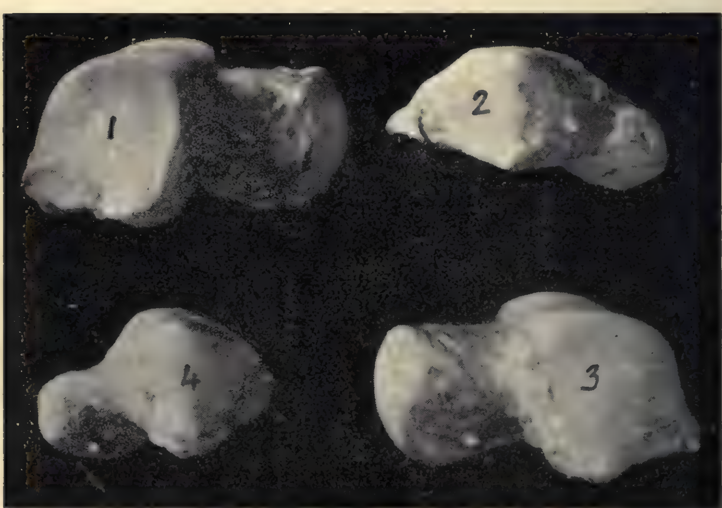


FIG. 71.—PHOTOGRAPH OF ASTRAGALI: 1 AND 3 FROM CHILDREN WITH NORMAL FEET; 2 AND 4 FROM CHILDREN WITH CONGENITAL VARUS.

All are taken from the outer side, and the anterior portions of the trochlea have been placed as nearly horizontal as possible. The downward declination of the neck of the astragali (2 and 4) from the cases of congenital varus is well marked.

deflection of the neck still remains, and in consequence the foot cannot be brought *to* a right angle, much less *beyond* a right angle, with the leg.

To ascertain the angle of downward deflection we have followed the method of Mr. Parker for measuring the angle of inward obliquity (p. 82).

The astragalus is placed on its outer side between two parallel threads, the upper thread just cutting the most prominent part of the superior articular surface, the lower parallel with the posterior inferior articular facet. A third thread is then carried through the centre of the neck, parallel to its upper border; the angle formed by the meeting of the last thread with the upper of the two parallel threads is taken as the angle of downward deflection of the neck. This method, we admit, is but an imperfect and rough attempt to show the amount of downward deflection, but it serves, we think, to show that in talipes, and especially in intractable cases, a marked downward deflection of the neck does exist.

Our measurements are given in the accompanying table, in which is also set forth the angle of inward deflection of the neck and the length of the outer and inner edges of the neck.

TABLE OF MEASUREMENTS OF ASTRAGALI.

| Bone. | Inward Inclination of Neck. | Downward Inclination of Neck. | Outer Edge of Neck. | Inner Edge of Neck. |
|---|---|---|---|---|
| 1. Normal fœtal ... ... | 38°·5 | 0° | $\frac{4}{12}$ inch. | $\frac{3}{12}$ inch. |
| 2. Normal fœtal ... ... | 40°·5 | 0° | $\frac{7}{24}$ " | $\frac{6}{24}$ " |
| 3. Normal adult ... ... | 9° | 0° | 1 " | $\frac{3}{4}$ " |
| 4. Normal adult ... ... | 15° | 0° | $\frac{3}{8}$ " | $\frac{7}{8}$ " |
| 5. Normal adult ... ... | 20° | 0° | $\frac{7}{8}$ " | $\frac{7}{8}$ " |
| 6. Talipedic adult ... ... | 60° | 123° | $1\frac{1}{4}$ " | $\frac{1}{2}$ " |
| 7. Talipedic child ... ... | 46° | 139° | 1 " | $\frac{1}{2}$ " |
| 8. Talipedic fœtal ... ... | 68° | 111° | $\frac{5}{12}$ " | $\frac{5}{24}$ " |
| 9. Talipedic child of seven years of age ... ... | 52° | 126° | 1 " | $\frac{1}{2}$ " |
| 10. Talipedic child ... ... | 45° | 140° | $\frac{7}{12}$ " | $\frac{4}{12}$ " |
| 11. Talipedic fœtal ... ... | 42° | 160° | $\frac{3}{8}$ " | $\frac{3}{16}$ " |
| 12. Talipedic child of eleven years of age ... ... | 52° | 152° | $1\frac{1}{4}$ " | $\frac{5}{8}$ " |
| 13. Talipedic child ... ... | 46° | 135° | | |
| 14. Talipedic child ... ... | 46° | 140° | $\frac{13}{8}$ " | $\frac{6}{8}$ " |
| 15. Talipedic child ... ... | 39° | 131° | $1\frac{1}{8}$ " | 1 " |
| 16. Talipedic child . . ... | 43° | 146° | $\frac{15}{16}$ " | $\frac{10}{16}$ " |
| 17. Talipedic child ... ... | 40° | 142° | $\frac{13}{16}$ " | $\frac{8}{16}$ " |

The elongation of the neck in some of our specimens is undoubted, the neck measuring, in fact, more than half the antero-posterior length of the bone. In the normal astragalus it measures, roughly speaking, a little less than one-third of the whole length of the bone. In most of our specimens the outer border of the neck is double the length of the inner border.* In some specimens there is practically no distinction between the neck and head, the latter not swelling out slightly beyond the neck, as in the normal bone, but the head and neck together forming a blunted cone.

FIG. 72.—PHOTOGRAPH OF THE ASTRAGALUS FROM A CASE OF CONGENITAL VARUS IN AN ADULT. (No. 3,510, St. Bartholomew's Hospital Museum.)

The articular surface for the tibia extends posteriorly to the posterior edge of the bone, anteriorly to about the middle of the normal trochlear surface. A, The articular facet for the scaphoid ; B, articular facet for tubercle of scaphoid.

2. *The Head.*—The head is still more misshapen than in the infant, and the two facets replacing the normal globular surface are still more differentiated, meeting each other in front, in some specimens, at more or less of an acute angle. The outer unopposed facet is rough and irregular, having, as a rule, lost its

* In measuring the length of the neck in the normal astragalus a line was drawn from a mid-point in the globular articular head, parallel to the borders of the neck, to the mid-point of the anterior edge of the superior articular surface ; in the deformed astragali, from the ridge between the scaphoidal and unopposed facet on the globular head, also to the anterior border of the superior articular surface. In specimen No. 3,510 the neck is $2\frac{1}{2}$ inches longer on its outer than on its inner side.

cartilage and become covered in some instances by ligamentous adhesions. In consequence of the downward and inward deflection of the neck, the cartilaginous surface for the scaphoid looks almost directly inwards and downwards. The head as a whole is much narrower transversely than normal. In some specimens a head can hardly be said to exist, the neck gradually narrowing and ending in a blunted cone, with the scaphoidal facet on its inner and lower side.

3. *The Superior Articular Surface.*—The anterior portion of the original superior articular surface is rough and irregular, in some instances denuded of cartilage and covered by ligamentous adhesions. The anterior edge of the new articular surface in extreme cases begins in the centre of the original trochlea, and is grooved antero-posteriorly by the anterior ligament. Posteriorly it is prolonged backwards quite to the posterior edge of the bone, except in very slight cases in which a non-articular ridge covered by ligaments separates the posterior surface from the posterior inferior articular facet. As a rule, the above-mentioned articular surfaces are continuous, the normal rounded posterior border of the bone being flattened out into a mere sharp edge, which, when the bones are *in situ*, is compressed between the os calcis and the posterior border of the articular surface of the lower end of the tibia. A distinct ridge has been described in some specimens, and we have noticed it in one of our own, as running transversely across the superior articular surface, and dividing it into two portions—an anterior denuded of cartilage, extruded from the ankle-joint, looking directly forwards, and, in our specimen, covered by ligamentous adhesions; and a posterior looking directly upwards, or upwards and slightly inwards, flattened, covered with cartilage, and extending quite to the posterior edge of the bone. In most of our specimens the ridge is not so distinct as this, but the cartilaginous superior surface bends down in an abruptly convex manner in front, so that the posterior two-thirds of the cartilaginous surface looks upwards, while the anterior third looks forwards. The anterior edge of the cartilage covering the superior surface in nearly all of our specimens, instead of ending, as in the normal astragalus, in a margin running transversely across the front of the body of the bone, runs obliquely forwards and inwards, and then protrudes as a tongue-like portion

on the upper, and to a slight extent on the inner, border of the neck, generally somewhat further forward on the neck than the front of the anterior end of the pear-shaped internal articular facet. This facet itself, both in the fœtus and the adult, is prolonged for some distance on the neck. Looked at as a whole, the superior articular facet, instead of presenting, as in the normal bone, a broad, almost quadrilateral surface, presents a narrow, elongated, almost triangular surface, with the apex of the triangle cut off behind. Whereas in the normal bone this surface is only a little broader in front than behind, in the bone of severe talipes it is nearly one-third broader in front than behind.

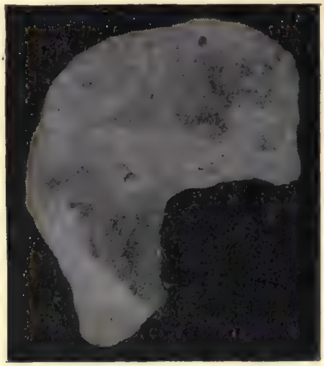

FIG. 73.—PHOTOGRAPH OF ASTRAGALUS (OUTER VIEW). (No. 3,510, St. Bartholomew's Hospital Museum.)

4. *The Inferior Surface.*—The posterior articular facet on the inferior surface has undergone marked changes. In the normal bone the long axis of this facet is directed forwards and slightly outwards. In varus, according to the severity of the case, the long axis of this facet is changed from the normal direction of forwards and slightly outwards, to directly forwards, forwards and inwards, and, lastly, in extreme cases, to almost directly inwards. This facet will be referred to again in speaking of the corresponding posterior articular facet on the upper surface of the os calcis. The facet is concave in the direction of its long axis in the normal bone. In the talipedic astragalus the facet may remain concave, the concavity following the long axis of the facet as this is changed, or it may be almost flat or become concave in its short

axis. In one specimen we found it divided by a ridge into an anterior and posterior part, the front surface being slightly concave, the posterior nearly flat. The anterior facet on the inferior surface of the astragalus, which is normally placed on the under surface of the neck and head, and corresponds to the facet on the sustentaculum tali of the os calcis, is generally smaller than usual. In some specimens it has disappeared entirely; in others it seems to have become blended with the posterior facet; in all it is nearer to the posterior facet than normal. The interosseous groove in consequence is either narrower at its posterior and inner end than usual, or at this part of the bone has altogether disappeared. The interosseous ligament in correspondence with the diminished size of the inner and posterior part of the interosseous groove is attenuated or absent.

As to the surface of the anterior facet itself, we have found it in some cases slightly concave, in others nearly flat, and in others, again, even convex. When present it has been situated further back on the neck than usual, or even on the body of the bone; whereas in the normal bone it is situated on the front of the neck and under surface of the head.

5. *The External Surface.*—The external articular facet for the fibula has been found considerably enlarged. In the adult specimen in our museum it is much reduced in size (Fig. 73). In our specimens removed from inveterate cases it is in nearly all increased in size—in some prolonged backwards as far as the posterior surface of the bone. The part which is extruded from the ankle-joint, and lies in front of the external malleolus, takes in many specimens the form of a distinct ridge or boss, which, when an attempt is made to dorsiflex the ankle, comes into contact with the external malleolus, and effectually prevents the articular surface of the bone from being replaced in its socket. We have clinically found this one of the chief obstacles in our attempts to overcome the equinus position. An enlargement of the anterior portion of the external facet which lies in front of the malleolus has been also noted by Rédard, who states that Nélaton has found it forming a distinct tubercle, or keel, preventing the replacement of the bone in its socket.

In a specimen examined by Mr. Adams this surface does not appear to have been enlarged, Mr. Adams merely remarking that

it was distinctly traceable, and that the external lateral ligament passed across it.

6. *The Internal Surface.*—In some cases the internal articular facet, as in the infant, is represented merely by a narrow articular ridge running along the upper margin of the internal surface immediately below the inner margin of the superior articular facet. In other cases the internal articular facet seems to have com-

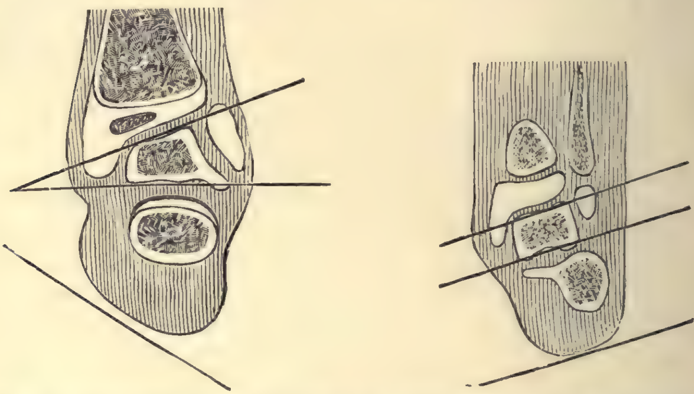

FIG. 74.—SECTION THROUGH THE HEEL OF A FOOT FROM A CASE OF CONGENITAL VARUS, COMPARED WITH A LIKE SECTION THROUGH A NORMAL FOOT. (After Redard.)

pletely disappeared, the deltoid ligament occupying the whole of the internal surface of the bone. This surface has been found to measure from above downwards less than it does in the normal bone. As a consequence of this, when a transverse vertical section is made through the centre of the body of the astragalus, the section of the body presents the appearance of a truncated wedge, with the base looking outwards. In the normal bone the section of the body at this situation appears almost square. The wedge-like shape of the astragalus in varus is well shown in the accompanying drawing, taken from Rédard. According to Rupprecht, the astragalus in severe cases of varus forms a sort of wedge placed between the tibia and the os calcis, with its apex looking inwards. This condition is considered by Rupprecht as one of the chief obstacles to rectification in inveterate cases, the wedge-shaped astragalus maintaining the inward rota-

tion of the sole, and thus preventing the plantar surface of the foot resting on the ground.

We have investigated the above point, and have found it hold good in some of the bones we have examined. Other astragali did not present the wedge-like shape. Contrary to what we should at first sight have expected, the wedge-like condition we have found more marked in infantile cases than in the bones of children who have walked on the foot. May this not be that in walking —seeing that the weight in varus is transmitted through the outer portion of the foot—the astragalus is more compressed on its outer than on its inner side, and thus loses its wedge-like shape through growth being promoted where there is least, and retarded where there is most, compression?

Returning to the internal articular facet, in some of our specimens it has been found prolonged posteriorly, where it has spread out and extended to the superior and inferior articular surfaces as well as quite to the posterior end of the bone. It has thus presented the pear-shaped articular surface of the normal bone reversed; that is, the base of the pear has been placed posteriorly, while the stalk portion has extended forwards along the upper margin of the internal surface of the bone. The stalk portion, of course, is the original posterior portion of the internal facet, the anterior part having been quite obliterated.

7. *The Posterior Surface.*—The posterior border is reduced to little more than a sharp ridge wedged in between the posterior border of the articular surface of the lower end of the tibia and the os calcis. The groove for the flexor longus hallucis has disappeared to a great extent in most specimens, in some completely.

**The Os Calcis.**—The os calcis has its posterior end drawn still more upwards than in the infant, so that in very severe cases its long axis is almost vertical in direction, and parallel, or nearly so, with the bones of the leg (Fig. 76). At the same time it is also further rotated on its vertical and longitudinal axes beneath the astragalus. Thus it is rotated on its vertical axis, so that its anterior end is carried inwards beneath (or behind in the talipedic position) the head of the astragalus, whilst its posterior end or tuberosity is carried outwards, and lies almost entirely behind the external malleolus, instead of behind the posterior sur-

face of the tibia. It is rotated on its longitudinal axis in such a way that the plantar surface looks inwards as well as downwards,

Fig. 75.—Photograph of a Specimen of Adult Congenital Varus. (No. 3,510, St. Bartholomew's Hospital Museum.)

The almost vertical position of the os calcis is well seen. The lines of the articulations have been marked with white paint to make them more distinct.

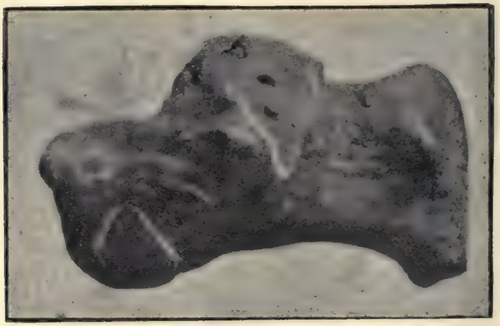

Fig. 76.—Photograph of the Os Calcis from a Specimen of Adult Congenital Varus (Oblique View). (No. 3,510, St. Bartholomew's Hospital.)

or backwards in the talipedic position, and its concave inner surface looks upwards or forwards, when the bones are *in situ*, as well as

inwards.* Looked at from the front, the anterior end of the bone is seen to be almost vertically below (behind when the bones

FIG. 77.—PHOTOGRAPH OF THE SAME OS CALCIS AS THAT IN FIG. 82 (PLANTAR VIEW). (No. 3,510, St. Bartholomew's Hospital Museum.)

FIG. 78.—PHOTOGRAPH OF OS CALCIS FROM A CASE OF VARUS IN A CHILD (SUPERIOR VIEW).

* Mr. Adams (*op. cit.*, p. 165) has not detected any lateral rotation inwards or outwards of the os calcis.

are *in situ*) the head of the astragalus, instead of below and external to the head of the astragalus as in the normal foot.

The alterations in the shape of the bone will next be considered under the following heads:

1. *The Size of the Bone.*—The bone is much smaller than normal. Its posterior part, especially that portion lying behind the superior articular surface, is, as a rule, particularly ill developed.* Hence the small size of the heel so characteristic of the deformity.

2. *The Superior Surface.*—The posterior and larger of the two superior articular facets, instead of being placed as in the normal os calcis, almost midway between the anterior and posterior extremity of the bone, and occupying about the middle third of the superior surface, lies, in the majority of the specimens we have examined, altogether behind a mid-point on the superior surface, and extends almost to the posterior border.† This apparent backward displacement of the posterior superior facet seems to be the result of the non-development or atrophy of the posterior third of the bone, rather than the result of any actual shifting backwards of the articular surface itself. In the infant we have not noticed the same suppression, as it were, of the posterior third of the bone, and we therefore assume that though the infant's heel in talipes is always small, this shortening of the bone between the posterior superior facet and the tuberosity, when it occurs, is the result of wasting rather than of non-development.

The long axis of the posterior superior articular facet is directed in the normal bone forwards, and slightly outwards (Fig. 79). In varus the direction of the long axis is changed. In slight cases it runs in the normal direction forwards and slightly outwards, perhaps a little more directly forwards than usual. In more severe cases the long axis runs directly forwards and backwards; in still more severe, forwards and inwards; and in the most extreme cases almost directly inwards; that is, almost inwards and outwards or transversely across the bone. The alteration which

* It is not so in specimen No. 3,510 in our museum.

† In No. 3,510, in our museum, the posterior third of the os calcis is well developed, and the superior articular facet is situated midway between the anterior and posterior ends of the bone as usual.

occurs in the long axis of this facet is shown in the accompanying diagram (Fig. 79).

Thus, it will be seen that the direction of the long axis of the facet varies with the severity of the case, and it reconciles what appeared to us a difficulty when on examining a number of talipedic specimens, we found that the long axis of this facet had so many different directions. It is not, we take it, that the facet is bodily shifted, but rather that in the rotation of the os calcis under the astragalus on an oblique axis running through the bone from the external tubercle on the tuberosity to the front of the sustentaculum tali, the anterior and outer portion of the original facet is gradually left unopposed, and loses its articular character, whilst the facet is gradually prolonged in a forward and finally

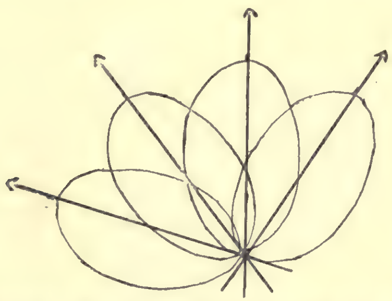

FIG. 79.—TO SHOW THE DIFFERENT DIRECTIONS OF THE POSTERIOR SUPERIOR ARTICULAR FACET ON THE OS CALCIS IN VARYING DEGREES OF SEVERITY OF TALIPES VARUS.

inward direction, as fresh surfaces of the bones are thus brought into contact. That this view is correct is further borne out by the fact that the superior articular facet is prolonged on to the inner surface of the bone, where it extends downwards for some little distance immediately behind the sustentaculum tali. In the intractable case (No. 3,510) in our museum it extends completely on to the posterior surface of the sustentaculum tali. In the normal bone the posterior superior facet is convex in its long axis in correspondence to the concavity in the long axis of the posterior facet on the inferior surface of the astragalus. In the talipedic os calcis this facet is convex in its short diameter, and becomes flat or slightly concave in its long. The outer part of the

facet looks upwards; the inner part, namely, that prolonged over the inner surface of the bone, looks upwards and inwards, or even directly inwards. The normal facets on the os calcis and astragalus allow of slight lateral rotation of the os calcis on the astragalus. In the talipedic bones in our possession, in consequence of the prolongation of the posterior facet on to the inner surface of the os calcis, very free rotation of the os calcis


Fig. 80.—Photograph of Os Calcis from a Case of Congenital Varus in Adult (Upper Aspect). (No. 3,510, St. Bartholomew's Hospital Museum.)

There is only one articular facet on the upper aspect, viz., the original postero-superior facet for the astragalus. It is seen to have altered its contour and direction, having disappeared anteriorly, and extended inwards on to the sustentaculum tali. A, Sustentaculum tali; B, anterior facet for neck and head of astragalus only faintly apparent. In place of a well-defined hollow in front of the posterior facet, the bone is almost level, though uneven. Observe the obliquity of the posterior portion of the bone.

on the astragalus, both in the vertical and antero-posterior axes, is permitted. In severe cases, and especially in the intractable case (No. 3,510) in our museum, this facet lies with its long axis directed inwards and slightly forwards, and is so prolonged

towards the sustentaculum tali, that the prolongation of the facet on to the inner surface is in a direction backwards as well as inwards, rather than inwards. Whilst, therefore, its outer half looks upwards, its inner half looks backwards, upwards, and inwards, or even backwards and inwards. We are not aware that these alterations in the facets on the superior surface of the os calcis and under surface of the astragalus have previously been described.

The *anterior facet*, which is usually situated on the sustentaculum tali, is altogether in front of the posterior facet, whereas in the normal bone the facet on the sustentaculum lies to the inner side of, and corresponds to the anterior half of, the posterior facet. This altered relation of the posterior to the anterior facet would appear to depend on the anterior portion of the posterior facet having been obliterated, and not on a mere change in their relative positions. In consequence of the diminution in extent of the posterior surface forwards, the non-articular portion of the upper surface of the bone is much lengthened, but at the same time it is less hollowed out than in the normal bone. The interosseous ligament which forms the pivot round which the bone rotates is confined almost entirely to this surface, the groove for the ligament, between the posterior articular facet and the facet on the sustentaculum, being almost obliterated, and the ligament itself here less developed than normal. In some specimens the anterior facet is fused with the posterior, or has altogether disappeared (see *Astragalus*, p. 106).

Behind the posterior articular facet the superior surface of the os calcis, or, as it is sometimes called, the upper border of the tuberosity, articulates with the external malleolus of the fibula, on which there is a corresponding facet formed. In some of our specimens this articular facet on the os calcis for the external malleolus is surrounded by a capsular ligament.

3. *The External Surface.*—This surface is slightly convex, and presents nothing of importance beyond that the grooves for the peronei are much deeper and more distinct than on the normal bone, and that its anterior end is bent somewhat inwards. The anterior end thus projects beyond the articular surface of the cuboid, and is an obstacle to the replacement of the cuboid in its normal relationship to the bone.

4. *The Inferior Surface*, in place of presenting two almost straight and parallel edges, has its outer edge slightly convex, its inner slightly concave, in correspondence with the bowing of the whole bone inwards in its long diameter. The inner and outer tuberosity present nothing particularly noticeable; but the depression at the anterior end of this surface for the short calcaneo-cuboid ligament is shifted altogether on to the internal surface, whilst its place is taken by the continuation of the groove for the peroneus longus from the outer surface.


FIG. 81.—PHOTOGRAPH OF THE ASTRAGALUS, OS CALCIS, AND CUBOID, FROM A CASE OF CONGENITAL VARUS IN AN ADULT (FRONT VIEW). (No. 3,510, St. Bartholomew's Hospital Museum.)

1. The astragalus. 2. The anterior aspect of calcis. 3. Outer aspect of cuboid (original dorsal surface).

5. *The Anterior End*.—In the infant we have seen that the anterior cuboidal end of the os calcis looks forward and inwards instead of directly forwards as in the normal bone. In the child who has walked on the foot this articular surface looks still more inwards, and in the inveterate case in the adult in our museum, is altogether on the inner surface of the bone. Looking at this

adult specimen, it might be thought that the whole of the anterior end of the bone had been bent inwards so as to bring the articular facet on to the inner surface; but when the changed position of the anterior cuboidal facet is traced through a series of specimens, it becomes evident, we think, that the altered direction of the facet is due in chief part to the cuboid being drawn round on to the inner surface of the bone, and giving rise, as it is gradually shifted, to atrophy of the inner part of the anterior end of the os calcis, and hypertrophy with heaping up of bone of the outer portion of the anterior end. In the adult specimen above referred to, the anterior end of the bone is completely non-articular, uncovered by the cuboid, and directed vertically downwards. It forms a globular projection in place of the sharply-margined concavo-convex articular surface. On this prominence the patient walked during life.

6. *The Posterior End.*—Looked at from behind, the posterior end, in place of presenting the somewhat quadrilateral irregularly convex surface of the normal bone, rough about its middle for the attachment of the tendo Achillis, and smooth above at the situation of the bursa, presents a concave inner and a convex outer border; whilst the tendo Achillis is attached to a ridge running not transversely, but obliquely, across the surface of the bone from the external superior angle above to the inferior internal angle below. The lower margin of this surface slopes upwards and inwards, so that the external tuberosity when the bone is held with the tuberosities downwards is the nearer to the ground.

7. *The Inner Surface* is more concave than natural, and the internal tuberosity projects inwards, making the surface look more concave than it really is. The anterior cuboidal facet is partially, in severe cases completely, on the inner surface. The sustentaculum tali overhangs the inner surface above as in the normal bone, but instead of being situated near the anterior end of this surface appears almost centrally placed, in consequence, it would seem, of the deficient development of the posterior third of the bone. The sustentaculum tali is also nearer the inferior surface than normal, apparently in consequence of its having been depressed, since when the bone is held horizontally the sustentaculum tali, together with the anterior portion of the posterior facet, appears to have been bent downwards and inwards, and is considerably

below the most prominent outer and posterior portion of the posterior facet.

There is in extreme cases a distinct articular facet on the anterior part of the sustentaculum tali for the displaced cuboid, and on to the back of this process the posterior facet for the astragalus is prolonged. The inner third of the posterior facet, as already stated above, encroaches on the inner surface.

The deep depression for the short calcaneo-cuboid ligament, usually situated on the inferior surface, seems to have been shifted altogether, in correspondence with the rotation of the cuboid, on to the inner surface of the bone; whilst the situation which it normally occupies is taken by the groove for the peroneus longus, which is prolonged from the outer across the inferior surface instead of passing from the outer surface directly on to the cuboid in the normal manner.

**The Scaphoid** is drawn inwards still further than in the infant, and lies parallel and to the inner side of the head of the astragalus, instead of in front of it, resting in extreme cases on the sustentaculum tali, the long axes of these bones, as Mr. Adams puts it, being parallel, instead of at right angles, to each other. The tuberosity is in slight cases somewhat increased in size, and there is a distinct facet on it for the internal malleolus. M. Rédard has found the tuberosity, in consequence of its compression between the astragalus and the internal cuneiform on the one side, and the internal malleolus on the other, so wasted that it was unrecognisable. This is also the case in our specimen of adult intractable varus, already so often referred to.

**The Cuboid.**—This bone we have already seen is in the infant very little altered either in shape or position; but in the foot that has been walked on, and especially in inveterate cases in the adult, it becomes altered both in shape and in position. The chief alteration in position is that it is displaced inwards from the anterior end of the os calcis on to the inner surface of that bone (Fig. 84), coming into contact in severe cases with the sustentaculum tali; at the same time it is so rotated on its postero-anterior axis that its dorsal surface is in contact with the ground, whilst its inferior or plantar surface looks, in severe cases, obliquely backwards and upwards.

The bone in our specimen is much reduced in size, but retains

its normal shape, except that the backwardly-projecting inferior internal angle is truncated, and presents a distinct facet looking backwards and inwards for articulation with the sustentaculum tali. This truncated condition is apparently due to

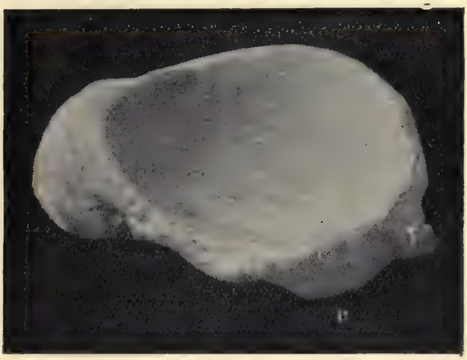

FIG. 82.—PHOTOGRAPH OF A NORMAL SCAPHOID (POSTERIOR VIEW).*

pressure; as the cuboid is gradually shifted from the anterior to the inner surface of the os calcis, the projection has come into contact with the sustentaculum tali, and has been gradually absorbed by pressure between this process and the rest of the

A

FIG. 83.—PHOTOGRAPH OF A TALIPEDIC SCAPHOID FROM BEHIND.
A, New articular facet on tubercle of scaphoid.

cuboid itself. On the *under surface* the groove for the peroneus longus is well marked. In a specimen in our possession this

* This bone and several of the following were enlarged during the process of being photographed for the purpose of clearness.

tendon lies in the groove. The *posterior end* is distinctly altered. In place of the concavo-convex facet for the anterior end of the os calcis, in severe cases two facets are present, separated by a

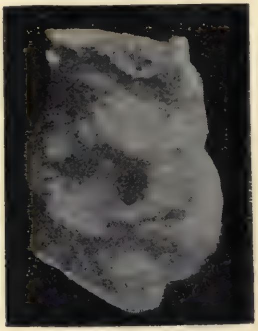

FIG. 84.—PHOTOGRAPH OF THE CUBOID (PLANTAR VIEW). (No. 3,510, St. Bartholomew's Hospital Museum.)

distinct edge. The outer and larger facet represents the outer half of the normal facet; the inner and smaller is the new facet formed for the front part of the sustentaculum tali on the sur-

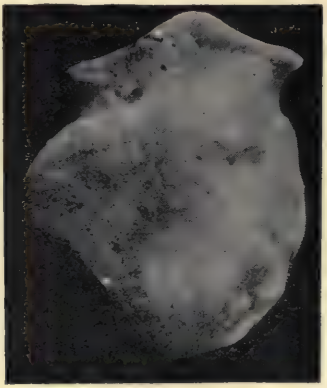

FIG. 85.—PHOTOGRAPH OF A NORMAL CUBOID (PLANTAR VIEW).

face of bone left by the absorption of the inferior internal angle. The ridge between the facets is rendered more pronounced in consequence of considerable absorption, from pressure, of the bone corresponding to the outer half of the original concavo-

convex facet. In our specimen of adult varus the plantar edge of this facet corresponds with the posterior ridge of the groove for the peroneus longus.

**The Cuneiform Bones.**—These bones follow the scaphoid, and

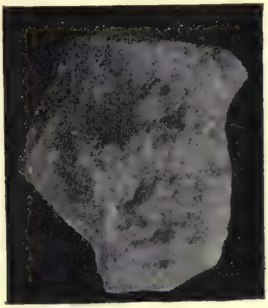

Fig. 86.—Photograph of Cuboid, showing Formation of New Articular Surface on Postero-Inferior Projection. (No. 3,510, St. Bartholomew's Hospital Museum.)

are not much altered in shape. Their dorsal surfaces have been said to be somewhat more developed than their plantar, but there is no evidence of this in our specimens. The margins of

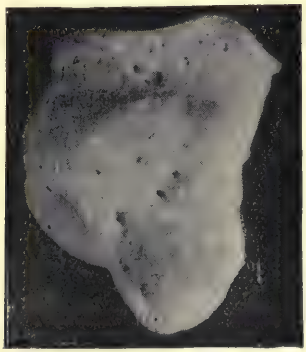

Fig. 87.—Photograph of Normal Cuboid placed in same Position as the Varus Cuboid in Fig. 86.

the dorsal surfaces are rounded, giving, as pointed out by Mr. Adams, an appearance of separation of the bones. At the junction of the original internal and superior surface of the internal

cuneiform bone there is in severe cases an articular facet for the internal malleolus, under which process the internal cuneiform is drawn.

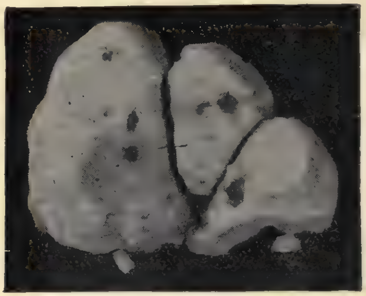

Fig. 88.—Photograph of the Cuneiform Bones (Posterior View). (No. 3,510, St. Bartholomew's Hospital Museum.)

The posterior articular facets of these bones are said by Hoffa* to run obliquely backwards, instead of vertically backwards, so that the facets can be seen from above.

Fig. 89.—Photograph of Normal Cuneiform Bones (Posterior View).

On the internal cuneiform bone the anterior surface, instead of looking directly forwards when held in the normal position, looks forwards and slightly inwards, and the anterior articular facet is prolonged somewhat on its inner surface.

**The Metatarsal Bones.** — The metatarsal bones are carried

* Hoffa, 'Lehrbuch der orthopaedischen Chirurgie,' p. 651.

inwards with the cuneiform bones and cuboid. They are said by Mr. Adams to hold their normal relations to the cuneiforms and cuboid. In a broad sense this appears to us to be the case. Nevertheless their posterior articular facets are more oblique than normal, the inclination of the facet inwards being exaggerated.

**The Phalanges.**—These, like the rest of the bones of the foot, are slightly atrophied ; but with the exception of the last phalanx of the great toe, which has been found* twisted obliquely downwards in consequence of the pressure of the boot, present no marked alteration in shape.

**The Alteration in the Position of the Bones as a whole, and to each other.**—As in the infant and child who has not walked, the displacement of the bones occurs chiefly at the ankle and at the subastragaloid and transverse tarsal joints. The astragalus is tilted forwards, downwards, and a little inwards from its socket, so that it assumes an almost vertical position. The os calcis follows the astragalus in its movement of plantar flexion, and thus also assumes an almost vertical position, its tuberosity pointing upwards, and its anterior end, left uncovered by the inward displacement of the cuboid, touching the ground. At the same time the os calcis with the rest of the tarsal bones (except the astragalus) is adducted and rotated inwards at the subastragaloid joint, so that whilst its elevated tuberosity is displaced outwards behind the external malleolus, its anterior depressed end looks inwards as well as downwards. The scaphoid and cuboid not only follow the astragalus and os calcis in the movement of plantar flexion at the ankle-joint and in the movements of adduction and rotation at the subastragaloid joint, but are also further directly adducted at the transverse tarsal joint. In consequence of these movements the dorsal surfaces of the bones look forward and downwards instead of upwards. The scaphoid comes to rest on the inner side of the head of the astragalus, having its long axis parallel to the bones of the leg instead of at a right angle to them, whilst the cuboid is shunted on to the inner side of the os calcis instead of lying in front of that bone. The cuboid is also so rotated in consequence of the transmission of the weight to the ground that its dorsal surface looks downwards instead of upwards and outwards.

* Adams, 'Club-foot,' p. 176.

Fig. 90.

Fig. 91.
For description of these figures see pp. 99 & 100 respectively.

The cuneiform bones with the metatarsal bones and phalanges follow the scaphoid and cuboid, retaining their normal relation to these bones and to each other, though in consequence of the inward displacement of the scaphoid and cuboid they are placed more or less at a right angle to the bones of the leg, and in extreme cases may have an inclination upwards. The metatarsal bones have their dorsal surfaces turned to the ground. The first metatarsal bone is approximated to the fifth as the result of the patient walking on the side of the foot, and thus the transverse arch of the foot is narrowed and the longitudinal furrow produced described on p. 57. The fifth metatarsal bone is rotated along with the cuboid as the result of the weight being transmitted to the outer side of the foot. The heads of the metatarsal bones are drawn nearer to the tuberosity of the os calcis and fixed in this position by the contraction of the plantar muscles and ligaments.

**The Ligaments.**—What has already been said concerning the ligaments in the foot of the infant applies with still greater force to the ligaments in the child who has walked on the foot, and in inveterate cases in the adult. The ligaments which in the infant are found shortened are still further shortened in consequence of the continued approximation of their ends, and become tough and fibrous with advancing growth and development. The ligaments chiefly concerned in holding the bones in their abnormal position are the *internal lateral*, the *calcaneo-scaphoid*, the *calcaneo-cuboid*, the *interosseus ligament*, and the *posterior ligament*, so called, of the ankle-joint. The ligaments, perhaps, above all others which maintain the foot in the varus position are those around the astragalo-scaphoid joint. These ligaments become abnormally blended together, and are called by Mr. Parker the astragalo-scaphoid capsule, which is thus described by him.* The capsule is 'made up above and internally by a blending together of the superior astragalo-scaphoid ligament with fibres from the anterior ligament, and the anterior portion of the deltoid ligament of the ankle-joint; below with fibres from the inferior calcaneo-scaphoid ligament. To these are united fibrous expansions of the tendons of the anterior and posterior tibial muscles. Together they form an unyielding capsule of great strength, which is attached to the

* Parker, *op. cit.*, p. 63.

several bones, not in the usual manner, but in adaptation to their altered relative positions.' Abnormal ligamentous bands have also been noticed passing from the internal malleolus to the scaphoid, and thence to the internal cuneiform bone, and blending by their deep fibres with the superior astragalo-scaphoid ligament. When all the other soft parts have been removed, these dense ligamentous bands on the inner side have been found sufficient to prevent eversion of the foot. The long and short calcaneo-cuboid ligament and the Y ligament are also abnormally shortened, and, like the ligaments on the inner side of the foot, are especially concerned in maintaining the deformity. The short dorsal and plantar ligaments uniting the internal cuneiform with the scaphoid and first metatarsal bone also help, but in a less degree, to keep up the inversion. The posterior ligaments, so called, of the ankle-joint, *i.e.*, the thin ligamentous bands stretching between the tibia and posterior surface of the astragalus, are thickened and contract adhesions to the superior surface of the os calcis. The posterior fasciculus of the external lateral ligament is also shortened, and holds the astragalus by its posterior end in close contact with the tibia and external malleolus. The contracted condition of the latter ligament appears to have escaped previous notice. It is evident to us that it holds the astragalus in the position of inward rotation on its transverse axis. The posterior ligaments are believed by some to be essential factors in maintaining the equinus position of the foot. They have, no doubt, a considerable share in so doing in the infant, but in relapsed and uncured cases the deflection of the neck and the locking of the bones due to the ridge on the anterior part of the external malleolar surface and the alteration in the anterior part of the trochlear surface of the astragalus, have more, we think, to do with it. We have found after the posterior ligaments have been divided, together with the posterior fasciculus of the external lateral ligament, that although the posterior articular surface of the tibia could be separated to some extent from the astragalus, still, the astragalus, in consequence of the abnormalities above mentioned, could not be replaced in its socket.

Finally, as in the infant, the ligaments on the outer side and on the dorsum of the foot have been found stretched and elongated. Amongst these may especially be mentioned the dorsal and ex-

ternal calcaneo-cuboid ligaments and the anterior ligament of the ankle-joint.

*The Plantar Fascia.*—In children who have walked on the foot, and especially in relapsed cases and in adults, the plantar fascia is always shortened and tense. The central as well as the inner portion of the fascia is affected, the one holding the metatarsal bones back towards the os calcis, and the other helping to maintain the inversion of the foot.

**The Muscles and Tendons.**—The *muscles*, partly in consequence of the defective nutrition of the whole limb, partly as the result of want of use, and partly on account of their shortened condition, become wasted, and to some extent atrophied, but do not undergo, as a rule, any fatty or other structural alteration. The anomalous conditions occasionally met with, as paralysis, fatty degeneration, etc., were mentioned in speaking of the muscles in the infant (see p. 94).

All the muscles below the knee are more or less thrown out of use by the rigidity of the ankle and subastragaloid joints. The calf muscles are shortened and wasted, the tibials are in a similar condition, and the extensor and flexor muscles of the toes are perhaps to a somewhat less extent affected. The peronei have been said to be elongated, but when the position which the bones assume is considered attentively, it will be seen that their ends are to some extent approximated, and consequently that they must with the other muscles be shortened.

The muscles of the sole, especially the abductor hallucis, are shortened and contracted, and tend to keep up the deformity.

The most important consideration, perhaps, in connection with the muscles is that as a rule they undergo no structural alteration, and that when the deformity has been overcome and the normal movements of the joints have been again brought about, they are capable under massage, electricity, etc., of being completely, or almost completely, restored to their normal function if not quite to their normal size. Of course, the longer the deformity has been allowed to remain untreated, the more the muscles with the other tissues of the limb will suffer, and consequently the less likelihood there is of complete restoration of function and size. This is another reason, if such were required, for the early rectification of the deformity.

*The Tendons.*—What has already been said of the altered relations of the tendons in the foot of the infant applies also to the foot that has been walked upon. The sheaths of the tendons are thickened, and the osseous grooves in which some of them lie are deepened and more pronounced. The groove on the back of the astragalus, for the flexor longus hallucis, however, is generally obliterated (p. 109). The deep grooves on the os calcis for the peronei have already been pointed out (p. 115). All the tendons are longer in consequence of the wasting of the bellies of the muscles, and more slender on account of their defective nutrition.

The alterations in the course of the tendons in the foot that has been walked on are so similar to those already described in severe cases of varus in the infant that they need no further mention here (see p. 94).

**The Vessels and Nerves.**—Nothing further need be added to what has already been said at p. 97 on the altered condition and relations of the vessels and nerves. They are essentially the same in the foot that has been walked on as in the severe phases of the deformity in the infant.

**The Skin.**—The skin on the inner side of the foot becomes shrunken, contracted and wasted, and in itself in severe cases offers a formidable obstacle to the reduction of the deformity. On the outer side of the foot, on the other hand, the skin is stretched, and becomes thickened, forming callosities, beneath which adventitious bursæ, especially over the cuboid and the anterior end of the os calcis—that is, over the points of bone through which the pressure is transmitted to the ground—are invariably formed. The large bursa over the above-mentioned bones (see Fig. 46) may be said to be characteristic. The pressure areas described by Volkmann and others are referred to under Etiology (p. 71). In long-standing cases intractable ulcers may form over the parts subjected to pressure.

## DIAGNOSIS AND PROGNOSIS OF CONGENITAL TALIPES VARUS.

*Diagnosis.*—An ordinary case of congenital varus, once seen, can hardly be mistaken for any other deformity. In later life, where

the deformity has been neglected, and the muscles in consequence have undergone more or less atrophy and the limb is wasted, the congenital may have to be distinguished from the paralytic variety. The history of one being congenital and the other having come on in early childhood after some illness, as measles, a fit of convulsions, or during teething, will put the surgeon on the right track. The physical condition of the limb in paralytic cases, namely, the bluish congested appearance, the cold clammy feel, and the paralysis of certain muscles as demonstrated by electrical tests, will further aid in the diagnosis. Another point especially laid stress on by Mr. Adams is the general rounded appearance of the foot in paralysis, and the absence of the irregular prominence on the dorsum and of the longitudinal and oblique furrows in the sole so characteristic of the congenital form. In those congenital cases, fortunately only exceptionally met with, in which there is congenital paralysis of the muscles, the history of the case, when it can be obtained, will settle the question. The presence of other congenital conditions, as spina bifida, absence of one of the bones of the limb, or absence or fusion of one or more of the toes, will further point to a congenital origin. The diagnosis of congenital varus from hysterical, spastic, cicatricial, and other acquired forms of varus is given under the head of Acquired Varus.

*Prognosis.*—The prognosis of congenital varus will depend on the period at which treatment is undertaken, the degree of the deformity, the state of the muscles, the previous treatment, the condition in life of the parents, and whether the patient has or has not walked on the deformed foot. When the treatment is begun early, during the first few weeks of life; when the deformity is slight or only moderate in severity; when the muscles are normal and the parents are able to look well after the child, the prognosis is most favourable. A complete and perfect cure may be obtained, and except, perhaps, that the leg may be a trifle smaller than the opposite leg, and the heel a little less in size than the other heel, no difference should exist between the sound and previously deformed leg. In the severer grades of the deformity the results may be less good. But still the foot should be plantigrade and the inversion and plantar flexion almost entirely overcome. When the treatment has been delayed for many

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months, or the case has been allowed to relapse or has never been completely cured, or when the condition in life of the parents is such that attention to the after-treatment cannot be properly given, and especially when the patient has walked on the foot, the result will be still less perfect. Some inversion will probably remain, the foot will not go beyond a right angle with the leg, and without the use of instruments relapses will continually occur. In them and in the most intractable cases, something may still be done by one or other of the severer operations to be mentioned under treatment; but the results thus obtained cannot be compared to those that should follow milder measures systematically and perseveringly carried out from the earliest period of infancy. When the muscles are affected, a very rare condition, but still one occasionally met with, the results must necessarily be imperfect, although massage and electricity may do something to restore those muscles which are less deeply affected by the congenital paralysis, and an instrument may enable the patient to walk fairly well. In extreme and intractable cases in the adult, where from want of use the muscles have become much wasted, and ulcers have formed over the prominent points of bone on which the patient has been accustomed to walk, nothing short of removal of the foot may suffice.

In those cases in the infant referred to under the heading of the Fourth Degree (p. 54) the probabilities of a successful issue are very doubtful. For such all kinds of treatment have been systematically and perseveringly tried, but the results have been far from gratifying.

To sum up: The prognosis will depend on the amount of rigidity and resistance experienced in overcoming the deformity with the hand. In the slighter degrees, where the foot can be thus easily rectified, an almost perfect result both as regards the shape and usefulness of the foot can be and should be obtained. On the other hand, where the rigidity is great, and the position of the foot can be but little improved on manipulation, the chances of success are less. If the resistance merely depends, as in the second degree of the deformity, chiefly on a contracted condition of the tendons, the prognosis is more hopeful than when it depends, as in the third degree, on shortening of the ligaments; whilst when the rigidity is in chief part due to the

abnormal condition of the bones, only an imperfect result at the best can probably be obtained. It will thus be seen that in forming a prognosis the amount of rigidity of the foot and resistance offered to rectification is of more importance than the mere outward appearance of the foot. A foot apparently much deformed may present very little rigidity, whilst one in which the deformity is outwardly slight may be exceedingly rigid. Further, we have to take into account on what the rigidity depends, whether on contracted tendons, shortened ligaments, or on deformed and altered bones.

## COMPLICATIONS OF CONGENITAL TALIPES VARUS.

The complications which may be met with in congenital varus are similar to those which occur in other congenital deformities of the foot. Amongst them may be mentioned hare-lip, cleft palate, spina bifida, encephalocele, meningocele, hydrocephalus, and as examples of the more severe congenital defects, anencephalus, absence of a limb, and the like.

## TREATMENT OF CONGENITAL TALIPES VARUS.

Our aim in the treatment of congenital talipes varus should be not only to restore the shape of the foot, but to retain it in the restored position until it shows no tendency to relapse, and the functions of the joints and muscles have been as far as possible regained. Before the foot has been walked upon, and the secondary changes already described have thus been brought about, and especially when the treatment is begun in early infancy, all slight and moderate degrees of the deformity can be and should be completely cured. The shape and usefulness of the foot should be restored, and except, perhaps, that the heel may be a trifle smaller than normal, and the leg not quite so well developed as the opposite leg, all other traces of the deformity should have disappeared. In severe cases, too, in the infant, with rare exceptions, an equally good result should be obtained. Where, however, the foot has been used in walking, except in the slighter phases of the deformity such a satisfactory cure cannot always be assured, and in severe and relapsed or

uncured cases in the child, and especially in the adult, it may be impossible to produce anything like a perfect cure, although a very fairly shaped and useful member may be gained.

To assure a satisfactory result, it is not sufficient merely to restore or improve the shape of the foot. The foot must be held in the restored or improved position by mechanical means until the normal functions of the articulations and muscles have been so far regained, and the bones in their growth have so far resumed their normal shape that there is no longer any tendency for the foot to fall back into the deformed position.

We have therefore first to consider the methods of restoring the shape of the foot, and secondly the after-treatment.

**The Methods of restoring the Shape of the Foot.**—These necessarily differ according to the degree and severity of the deformity and the period at which treatment is begun. They will be considered in detail under the heads of manipulative, mechanical and operative treatment; but before entering into these details it

FIG. 92.—PHOTOGRAPH OF THE FEET OF A CHILD AGED SEVEN WITH CURED TALIPES VARUS OF THE RIGHT FOOT, SHOWING SMALL CALF AND HEEL.

may be useful to first give a general outline of the treatment that may be called for according to the severity of the deformity and the period at which it is undertaken, especially mentioning the methods that have been found of most service by the authors in the Orthopædic department at St. Bartholomew's.

## A. General Outline of the Treatment of the Various Degrees of the Deformity in the Infant and Child before it has walked on the Foot.

**Period at which Treatment should be begun.**—In our opinion, the treatment of congenital talapes varus cannot be undertaken at too early a date. Indeed, we would endorse the dictum laid down by Professor Sayre, that treatment should be begun as soon as the infant is washed.* We are aware that many distinguished orthopædic surgeons hold different opinions, some maintaining that treatment should not be begun till just before the child is about to walk, whilst others fix the period at two months of age. The arguments for beginning at the earliest possible date are that at birth the bones are little more than cartilage, and can be then moulded and made to take almost any shape; the old articular surfaces have not been destroyed, and the ligaments are comparatively soft and yielding. No doubt the parts at this early period are delicate; but, then, our manipulations must also be delicate, and as far as our experience goes, both of orthopædic and of general surgery, infants bear operations exceedingly well. It is true that a young infant does not stand much loss of blood, but in any operation required at this tender age there need not, and should not, be practically any loss of blood. We therefore treat our cases at the earliest age we can.

**Treatment of the First Degree.**—In this degree the foot turns only slightly inwards, and the os calcis is but little, if at all, elevated. Indeed, the deformity is merely a slight increase of the normal inward inclination of the infant's foot at birth. These cases require little more than what can be readily done by the intelligent mother or nurse. By taking the foot in the hand, it can be quite easily, without using practically any force, placed in the normal position. The mother or nurse should be instructed to hold the foot in the palm of the hand from time to time whilst nursing the child, and at regular intervals to practise passive movements at the ankle, transverse tarsal and subastragaloid joints (see p. 139). At night the foot should be retained in the normal or in a slightly over-corrected position by a

* Sayre, 'Deformities.'

light well-padded tin varus-splint (p. 141), or be merely so fixed by a soft bandage wound in a figure-of-eight over the foot and ankle (p. 145). If a bandage is used, it should be applied from without inwards, as in this way each turn as it is carried over the foot and ankle tends to draw the foot outwards. These simple measures, intelligently carried out under the supervision of the surgeon, will, as a rule, suffice for the early and complete correction of slight degrees of the deformity. Should it be found, however, that no progress is being made after a few weeks' trial, the surgeon had better take the case entirely under his own care, and treat it in the way described under the next degree of severity.

*Other Methods of treating the First Degree.*—1. By mechanical apparatus alone (p. 141). 2. By elastic tension (p. 160). 3. By division of the tendo Achillis at once and correction by plaster of Paris (p. 146).

**Treatment of the Second Degree.**—Under this head we include cases in which the deformity, though not severe, is well marked. The foot turns distinctly inwards, and the os calcis is slightly elevated. When taken in the hand, the foot cannot be placed in its normal relation with the leg without using some amount of force. There is of course no hard-and-fast line between these and the cases previously described, nor, indeed, between these and the next class. Every degree of the deformity is met with, from that in which it is so slight that it is a question whether it should be called a deformity at all or merely an exaggerated condition of the normal inward deflection of the healthy infant's foot, to that in which it is so extreme that the dorsum of the foot is in contact with the leg. The division here made into degrees, though useful for the purpose of describing the treatment, is quite artificial. The degrees pass so insensibly into each other that it may be difficult to assign any individual case into any particular division. In the degree now under consideration, *i.e.*, when the foot with very slight pressure of the hand can be brought into line with the leg, though there still remains some drawing up of the heel that cannot be overcome by the hand, our routine treatment in the department has been to first overcome the varus by manipulation (p. 139) and plaster of Paris bandages (p. 146), and then to divide the tendo Achillis and place the foot at once, in the

best position into which it can be forced by the hands, in plaster of Paris. Subsequently the plaster has been reapplied weekly until the foot could be dorsal-flexed to a degree equal to that of the foot of the sound side, or, if both sides are affected, till the feet can be dorsal-flexed to an angle of thirty degrees. At each reapplication of the plaster the foot has been manipulated and the leg massaged. For the detail of the method of manipulation and application of plaster, the reader is referred to pp. 139, 146.

The time occupied in overcoming the varus by this method should be from a fortnight to a month or six weeks, according to the severity of the case; the time for overcoming the equinus somewhat longer. After the foot has been restored, a night-shoe (Fig. 94, p. 141) should be worn to counteract the tendency of the weight of the bed-clothes to press back the foot into the deformed position, and a boot with a leg-iron on the inner side (p. 230) employed during the day. The manipulations should be continued. When the child is about to walk, the leg-iron should be carried up to the thigh if the limb shows any tendency to roll inwards.

*Other Methods of treating the Second Degree.*—1. Some surgeons begin the treatment of slight degrees like that under consideration by first dividing the tendo Achillis. Amongst the advocates for this may be mentioned Mr. Parker, Mr. Owen, Dr. Marshall, and several American surgeons. There is no doubt much to be said in favour of the early division of the tendo Achillis. We have tried it in some cases, but on the whole prefer the method given above. 2. Some employ the methods of forcible manual or instrumental correction (p. 173). The latter, however, appears to us an extreme measure for so slight a degree. 3. Others trust to mechanical apparatus alone, or mechanical apparatus combined with division of the tendo Achillis (p. 194).

**Treatment of the Third Degree.**—In this degree the inverted foot cannot be brought completely into line with the leg, and the heel is considerably elevated. On attempting to correct the deformity, the tibial tendons and tendo Achillis are felt tense and resisting. Here, again, there is no hard-and-fast line between this degree and the former, and the first point to determine is what fasciæ, tendons or ligaments, if any, require division. Thus, if the foot with some amount of force can be brought

almost into line with the leg, and when held in this position the tibial tendons are not felt very tense, the deformity can be cured without their division. If also the sole of the foot feels soft and yielding to the fingers, and there are no contracted bands to be felt on the inner side of the sole, the division of the plantar fascia will not be necessary. The tendo Achillis, however, will always require division. On the other hand, if on attempting to straighten the foot the anterior tibial tendon is felt tense, it had better be divided, since by doing so the cure will be expedited. If, further, the internal malleolus is not rendered prominent on attempting to abduct the foot, tenotomy of the tibialis posticus, and perhaps of the flexor longus digitorum as well, will also be advisable. Lastly, if any tense bands are felt in the sole and on the inner side of the foot, their subcutaneous division may also be undertaken.

Our treatment, then, where the tibialis anticus is felt tense and the internal malleolus cannot be made prominent, has been in the first place to divide these tendons, and then to place the foot in a corrected position in plaster of Paris. The plaster is changed weekly until the foot remains of itself in line with the leg, or, still better, slightly over-corrected. Before each reapplication of the plaster manipulation of the foot and massage of the leg is advisable. After the foot has been brought into line with the leg, the tendo Achillis is divided, and the foot carried as far as possible into the dorsal-flexed position, and thus secured in plaster of Paris. The treatment onwards has then been that mentioned under the former degree (p. 134). In some cases where there has been much ligamentous rigidity on the inner side of the foot, we have practised for this degree syndesmotomy of the astragalo-scaphoid capsule before dividing the tendo Achillis.

*Other Methods of treating the Third Degree.*—1. Division of the tibials, tendo Achillis and plantar fascia at one sitting, and placing the foot corrected as far as possible in plaster of Paris or other apparatus. 2. Division, in addition to the above-mentioned tendons, of the astragalo-scaphoid capsule, posterior ligament of the ankle, and any other band that is felt tense, and placing the foot in plaster (Parker's treatment, p. 208). 3. Subcutaneous division of all the structures on the inner side of the sole down to the bones (Buchanan's treatment, p. 213), or of all the structures on

both inner and outer sides down to the bones (Lane's treatment, p. 213). 4. Forcible rectification and plaster of Paris (p. 173). 5. Open incision of the soft tissues on the inner side of the foot down to the bones (Phelps' operation, p. 215). 6. Mechanical rectification, with or without division of tendons (p. 141).

**Treatment of the Fourth Degree.**—In this degree the foot is firmly held in the varus position, and the heel is considerably elevated. On attempting to correct the deformity by the hand little or no impression is made upon it. This degree includes the most severe cases, in which the dorsum of the foot is in contact with the leg and the toes point upwards. For its treatment we have always made the attempt to correct the foot by the method mentioned in the former degree, and we have often been successful; but in some cases we admit that do what we would we have failed, and have had later in the case to perform some operation on the tarsal bones.

*Other Methods of treating the Fourth Degree.*—1. Phelps' open incision. 2. Lane's subcutaneous method. 3. Division of all contracted tendons, and the employment of mechanical apparatus for lengthy periods. 4. Forcible correction with the tarsoclast (p. 174).

### B. General Outline of the Treatment in the Child who has walked, and in the Adult.

In the child who has walked on the deformed foot, and in the adult, the treatment is more tedious, and seldom attended with the same good result as when undertaken in infancy. Many of these cases will come under the head of relapses, or, more correctly speaking, of only partially-cured cases. For relapses are very uncommon where the deformity has been completely cured in the strict sense of the word. In the majority of the so-called relapsed cases it will be found on careful inquiry that, although the deformity may be said to have been cured, some inversion remained, and the foot would not go in the direction of dorsal flexion beyond a right angle. In other cases of relapse it will be found that the after-treatment has been neglected—in short, that the bones had been completely replaced, but the foot had not been retained in the restored position sufficiently long by the use of instruments for the articular surfaces to become con-

solidated, and the bones to assume in the process of ossification their normal shape.

In the child who has walked on the deformed foot, if the case is of only moderate severity, we first divide the tibial tendons and flexor longus digitorum, and if necessary the astragalo-scaphoid capsule, and either at the same sitting or subsequently the plantar fascia and any tense bands that may be felt in the inner side of the sole of the foot. The foot is then well forced in the direction of abduction and dorsal flexion, and placed in plaster of Paris. At the end of a week it is further forcibly corrected and again placed in plaster of Paris. As soon as by these means the varus has been overcome, the tendo Achillis is divided and the foot forced as far as it will go in the direction of dorsal flexion and thus fixed in plaster. The forcible correction and plaster are continued till no further improvement is gained. In some of these cases, unfortunately, the foot cannot be dorsal-flexed beyond a right angle. For such we have tried not only plaster of Paris, but also, we think we may say, most of the mechanical appliances that have been described. The tendo Achillis when it has seemed necessary has been redivided, and the posterior ligament of the ankle divided subcutaneously. In spite of all that can be done and after long perseverance the foot will in some cases not come up beyond the right angle. In such cases it is clear that the obstacle to bringing the foot beyond the right angle is neither the contracted tendo Achillis nor the shortened posterior ligament. The hindrance lies partly in the downward deflection of the astragaloid neck, and partly in the outgrowth of bone on the outer side of the head and neck of the astragalus (p. 107) coming into contact with the external malleolus and so locking the parts. This can be verified both clinically and by examination of the specimens in the museums. For such cases some operation on the bones of the tarsus appears to us to be absolutely necessary.

The treatment of confirmed cases in the adult is still more difficult. Fortunately, they are not very often met with. In the less severe of these, after division of the tibial tendons and plantar fascia, and, if the foot does not then yield, of the astragalo-scaphoid capsule and any other resisting structure in the sole, the foot may be wrenched and placed in plaster of Paris, and as

soon as the varus has been overcome, the tendo Achillis may be divided and an attempt made to bring down the heel. If the surgeon prefers the use of instruments, the adult varus shoe devised by Mr. Adams may be employed (p. 169). These moderately severe cases can no doubt be greatly improved by the methods above indicated. As a rule, however, in the cases that have come under our personal notice, the deformity was so intractable and severe that nothing short of an operation on the bones was capable of restoring the foot to its normal shape and usefulness. In a few cases the limb was so wasted and useless that amputation had to be performed.

*Other Methods of treating Confirmed Cases are :* 1. Forcible in-

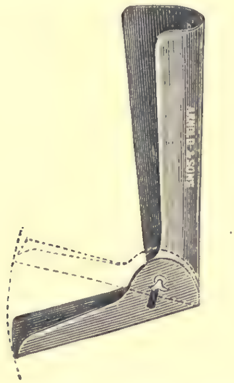


FIG. 93.—TIN SPLINT WITH MOVABLE JOINT FOR THE TREATMENT OF CONGENITAL VARUS (ARNOLD).

strumental correction. 2. Subcutaneous division of all the soft parts in the sole or on the inner side of the sole. 3. The open incision of Phelps. 4. Tarsotomy or tarsectomy.

We will now discuss in detail the various methods above referred to under the heads of — 1. Manipulative treatment. 2. Mechanical treatment. 3. Operative treatment.

1. **Manipulative Treatment of Congenital Talipes Varus.**— Manipulative treatment alone is only applicable to very slight cases of the deformity in the infant. For severe cases it is useless to waste valuable time over it, especially in the infant, since every week the deformity is allowed to remain and the bones to become consolidated in their abnormal shape and posi-

tion, the more difficult it becomes to completely cure the deformity.

The manipulation, except in the very slightest cases, in which it may be left to the mother or nurse, but under the surgeon's supervision, should be undertaken by the surgeon himself or by a properly-trained masseuse. It should be done for ten minutes to a quarter of an hour at a time, at least twice or three times a day, better still more frequently. During the intervals the foot should be held in the best possible position by means of either a bandage or a simple varus splint.

The splint may consist of tin, gutta-percha, poroplastic felt, or other suitable material. The one shown in the accompanying illustration (Fig. 93) will be found as useful as any. It should, of course, be well padded. This splint may also be worn with advantage during the night.

The surgeon, taking the foot in one hand and the ankle in the other, should gently but firmly move the foot first in the direction of abduction, then in that of adduction, and then repeat the movement. Each time that the foot is brought into the position of abduction it should be gently forced in this direction as far as it will go, but without causing much or any pain, and held thus for half a minute or so, in order to stretch the tibial tendons and ligaments on the inner side of the foot. When these movements at the subastragaloid joint have been practised for, say, five minutes, the heel being grasped, the fore part of the foot should be alternately dorsal- and plantar-flexed. During the movement of dorsal flexion, the foot should be gently forced as far as it will go in this direction, pressure at the same time being made in the direction of abduction as well as that of dorsiflexion. In this way the tissues in the sole and the ligaments connecting the bones entering into the transverse tarsal joint are put on the stretch. Next, attention should be turned to the ankle-joint proper. The surgeon again grasping the leg with one hand, whilst the palm of the other is under the sole of the infant's foot, alternately plantar and dorsal-flexes the whole foot, forcing it as far as it will go in the direction of dorsal flexion, and holding it thus for a minute or so. In this way the tendo Achillis and posterior ligaments of the ankle are put on the stretch. Finally, the whole foot should be circumducted, first inwards, then outwards. Massage of the

leg, especially of the anterior muscles and peronei, is advisable at the same sitting.

*Indications for Manipulation.*—The only cases in our opinion to which this form of treatment by itself is applicable are those in which there is practically no drawing upwards of the heel, and in which the foot when taken in the hand can be brought with hardly any resistance into a line with the leg, although it springs back to the varus position when the restraining hand lets go.

As an accessory to the more effectual methods of treatment of severe cases, manipulation is of the greatest service, and should always be practised when the retentive apparatus, whatever this

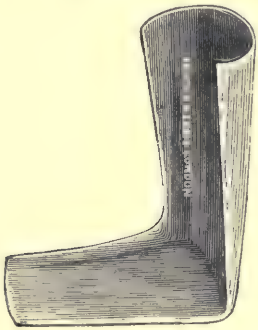


FIG. 94.—SIMPLE TIN VARUS SPLINT.

may be, is removed. At the termination of the operative and mechanical treatment manipulation with massage should be sedulously continued till the functions of the muscles and joints have been as far as possible restored (see Physiological After-treatment, p. 245). The splint shown in Fig. 93 or that in Fig. 94 should be worn as a night-shoe for six months or more, to prevent the weight of the bed-clothes leading to a relapse.

2. **Mechanical Treatment of Congenital Talipes Varus.**—The treatment of congenital talipes varus by means of mechanical apparatus has been in vogue since the days of Hippocrates, but it does not appear, except in slight cases, that much success was as a rule obtained by it. It has been stated that the fashion of bandaging the feet of Chinese female children for the purpose of

producing the deformity characteristic of the foot of the Chinese lady was instituted by an edict of one of the Emperors of China, who, having a daughter born with talipes, resolved that all ladies should have crippled feet—that the deformity in the Princess, which was looked upon as incurable, might not be noticeable. Even as late as the time of Lord Byron (born 1788), notwithstanding the efforts of Sheldrake and others to cure the defect by mechanical means, club-foot in its severer forms was looked upon as so intractable a malady that his lordship, it appears, soon gave up the treatment he was subjected to by his physicians, and resolved to put up with his deformity as best he might.

Indeed, the mechanical apparatus were so clumsy, heavy and complicated, so difficult of application, the time required for the cure was so excessive, some forms necessitating months or even years in the recumbent position, the pain inflicted was so severe, and swelling and bruising of the foot and leg and formation of abrasions and ulcers were so liable to occur, that the majority of regular practitioners had abandoned attempts at the cure of severe congenital club-foot, and its treatment was relegated to instrument-makers and empirics. Vernel in Switzerland, Tiphaisne and Verdier in France, and Jackson in England, about the end of last century, published successful cases cured by gentler means without pain; but a veil of secrecy seems to have been thrown over their methods and apparatus, and it is only from 1803, when Scarpa published his 'Memoir on the Treatment of Congenital Club-Foot,' that the scientific construction of any mechanical apparatus, founded on dissection, can be said to date. In this memoir was described the celebrated *Scarpa's shoe*, on the principle or model of which nearly all the modern apparatus have been based. Notwithstanding Scarpa's improved mechanical appliances, it was not until the introduction of Stromeyer's method of supplementing mechanical treatment by the subcutaneous division of tendons that any great success followed its use, and it was rather in combination with operative measures than alone that mechanical treatment for other than slight cases came to be employed. Since the days of Scarpa numerous forms of mechanical contrivances have been invented, all more or less on Scarpa's model. Whilst, on the one hand, some surgeons may be said to have aimed at the elaboration and improvement of

the original Scarpa's shoe and the correction of such principles as in it were at fault, others have directed their attention to simplifying the mechanical apparatus and methods of treating the deformity, and the simplest application of mechanical principles will, perhaps, be found in the use of plaster of Paris, or even ordinary bandages or strapping plaster.

Mechanical treatment, however simple or however elaborate the apparatus employed, has for its aim (1) the gradual stretching of any contracted tendons, ligaments, fasciæ or muscles that impede the restoration of the displaced bones to their normal position; (2) the gradual moulding or bending of any deformed bones into their normal shape; and (3) the maintenance of the bones in their normal position after they have been there placed by previous treatment. Thus, *where mechanical treatment is alone employed*, the restoration of the foot is brought about entirely by the stretching of the contracted tissues, whatever these may be, and the moulding of the deformed bones into a normal shape. When *combined with operative measures*, its use is either to stretch such structures as remain contracted after operation, the ligaments, for instance, after division of tendons, or to retain the bones in the normal position after they have been there placed by whatever operative procedure has been employed.

Further mechanical treatment is also necessary, in most cases, after the cure of the club-foot is complete, to prevent a relapse, but an account of this more properly comes under the head of Mechanical After-treatment (p. 227). For the scientific application of all mechanical treatment it is essential that the surgeon should know not only what are the structures that prevent the bones being replaced in their normal position, what are the bones that may themselves be deformed, but also what are the centres of motion at which the displacement of the bones has occurred. Thus in the application of mechanical force it should be always borne in mind that in the varus position, the inversion and rotation of the foot occurs at the transverse tarsal and subastragaloid joints; in the equinus position at the ankle-joint proper; and that in severe cases not only in children who have walked on the foot and in adults, but also it may be in infants, certain of the bones, especially the astragalus and os calcis, are themselves somewhat, it may be considerably, altered in shape. Mechanical force, there-

fore, whatever its nature, should be made to act on these centres of motion in such a direction as to push or draw the displaced bones towards their normal position, and at the same time to exert such pressure or traction on the misshapen bones as will tend to mould them into their normal shape. Some of the forms of apparatus to be presently described are constructed for correcting the varus position only, others the equinus; some endeavour to effect both objects at the same time. In some the mechanical force employed may be said to be of a *passive* nature, merely retaining the foot in an improved position, and the ligaments on the stretch. Amongst these may be mentioned simple bandaging or strapping, or retention in plaster of Paris or like material, the active force in such a case being entirely supplied by the surgeon's hands; in others the mechanical force is of an *active* and *continuous* character, as in the various forms of elastic tension apparatus, spring instruments, etc. In others, again, the application of both active and passive force may be said to be combined, as when the foot is confined in a shoe or splint, and the active force is exerted through the agency of springs, levers, or cogwheels.

We will now describe in detail the various forms of mechanical treatment, but before doing so we wish to state that, in our opinion, this method should only be used *alone* in the slightest cases. We do not deny that moderate, and even severe, degrees of the deformity can be cured by mechanical treatment alone, but the time consumed, the tediousness of the method, the trouble involved, and the expense incurred, are reasons why operative measures should always be combined with it. In very severe and intractable cases in children who have walked on the foot and in adults, we do not believe that a satisfactory cure *can* be obtained without operation.

The *mechanical treatment* will be considered under the heads of (1) simple bandages and strips of strapping; (2) plaster of Paris, silicate of potash, gum and chalk, dextrine and starch bandages; (3) poroplastic felt, gutta-percha, leather, and prepared cardboard cases; (4) combination of splints and bandages or strips of strapping; (5) elastic tension by means of rubber cords or rings; (6) cogwheel, spring and screw apparatus.

### (1) *Bandages and Strips of Strapping.*

*Treatment by Bandages.*—Bandaging alone is only applicable to the slightest cases in the infant. When resorted to, it should always be combined with the manipulative plan described at p. 139, and if there is any drawing up of the heel, with tenotomy of the tendo Achillis. It is chiefly useful in correcting the varus position. The bandage, which should consist of domett or flannel, should be about six yards long and an inch and a half to two inches wide. It should be wound over the foot and ankle from *without inwards*, so as to produce abduction and rotation of the outer border of the foot upwards at the transverse tarsal and subastragaloid joints. Starting on the outer side with a few turns round the leg, the bandage should be carried over the ankle and inner side of the foot, and then up round the outer side of the foot in the form of a figure-of-eight. Each turn should be passed somewhat lightly over the inner side of the ankle and foot, and then drawn tightly as it is brought up over the outer side of the foot and ankle. In this way the foot is drawn by the bandage into a position of abduction, eversion and dorsal flexion. The turn should be repeated until the foot as far as the toes has been enclosed in the bandage. By the careful use of the bandage for a few weeks, a slight varus position can be completely overcome. The bandage should be applied twice a day, and first by the surgeon himself, the mother and nurse in the meanwhile being instructed how to put it on. Before each reapplication the foot should be subjected to manipulation and massage in the way described under that head at p. 139.

*Treatment by Simple Strapping.*—Sayre and Meusel, amongst others, make use of adhesive plaster in the correction of the deformity, but this method, like simple bandaging, is only adapted for the treatment of very slight cases, and for fixing the foot after forcible rectification or tenotomy. A strip of stout diachylon plaster is taken, an inch to an inch and a half wide, and sufficiently long to surround the foot and pass up the leg above the knee; one end is wound obliquely from without inwards over the dorsum of the foot and then under the sole, and the foot having been forced by the hand as near as possible towards the corrected position, the strapping plaster is carried up the outside

of the leg as far as the head of the fibula and fixed by an ordinary roller bandage. To prevent the strapping plaster slipping, its upper end is folded back, with its adhesive side outwards, over the last few turns of the roller bandage, and is then covered in by a few turns of the roller. In applying the strapping the surgeon should be careful not to completely surround the foot, for fear of causing circular constriction. Our objection to this method is that, when patients are only seen in the out-patients' room, the diachylon plaster is apt to slip between the visits and to chafe the skin. Moreover, it is sticky, and requires turpentine or other solvents to cleanse the parts before the manipulation, which should always be practised previous to the reapplication of any apparatus, can be undertaken.

### (2) *Plaster of Paris, Silicate of Potash, Gum and Chalk, Dextrine and Starch Bandages.*

*Plaster of Paris.*—The method of correcting the deformity by means of plaster of Paris bandages may be employed either with or without operative treatment. When employed alone without any operative measures, the aim of the surgeon is to gradually stretch any resisting tendons, ligaments and fasciæ, to slowly replace the displaced bones, and to mould those that are misshapen into their normal shape. The foot at each application is gently forced by the hand into the best position approaching the normal that it can be made to assume without causing pain, and is thus held whilst the plaster bandage is being rolled on and until the plaster has firmly set. The plaster bandage keeps the foot in the corrected position into which it has been forced by the hand till the next application, when further correction by the surgeon's hand is again made, and the foot retained by the plaster in the still further improved position. The efficiency of the process will depend in part upon the frequency with which the plaster bandage is applied, and in part upon the amount of force that is used, and, above all, upon the care and skill with which each application is carried out. The plaster bandage acts in a way similar to any other mechanical contrivance which may be used for gradually correcting the deformity. It has, in our opinion, this great advantage over any appliance fixed by straps

and bandages, namely, that the pressure is diffused and uniform, more like that that can be exercised by the hand, and hence abrasions or sores are not so likely to be produced as when pressure is applied unequally, and often excessively, as it may be at certain spots by straps and padded irons.

For out-patient practice it is to our minds infinitely superior to all other forms of apparatus with which we are acquainted. When properly applied, it is certain not to come off or get loose between the visits of the patient. Pressure abrasions or sores are practically unknown. There is nothing to get out of order, no straps or bandages to become loose, no screws to require mending, and, above all, it is cheap.

We do not mean to say that equally good results may not be obtained by the splints, shoes, springs and cogwheel apparatus used by some surgeons, but we deny that better can be shown. Indeed, we have ourselves found such apparatus equally as efficacious as the plaster, but, then, we have applied them ourselves and daily reapplied them, having the patient under constant observation in the wards. But for out-patient work, where the patient cannot be seen every day, and where the application of apparatus must to some extent be left to the care of the usually overburdened mother at home, we have found that pressure abrasions and sores constantly occur. Not so, however, with plaster. After the dressers have been instructed in its proper application, we have not found any trouble of the kind. An intelligent dresser soon learns how the bandage should be applied, so that there is no danger, on the one hand, of injurious constriction, nor, on the other, of the infant kicking it off; and inspection by ourselves of each bandage before the patient leaves the hospital ensures that our treatment is being properly carried out.

*Method of applying the Plaster Bandage.*—A cotton-wool bandage is first evenly applied from without inwards to the lower half of the leg and foot, enclosing the ankle by figure-of-eight turns. The bandage is made by taking a sheet of cotton-wool and cutting it into strips three feet long and from three to five inches wide, according to the age of the patient. The strip of cotton-wool is next rolled up like an ordinary bandage, and is ready for use. The cotton-wool bandage having been applied

and the foot forced by the left hand of the surgeon, or by the hand of an assistant, into the improved position, we are now ready to put on the plaster of Paris bandage. After the bandage has been soaked in water (the inexperienced should use cold water, as the plaster then takes longer to set, and therefore gives them more time to carry out their manipulation), it should be applied to the lower part of the foot, just clear of the phalanges. Beginning at the outer side, two turns should be taken round the foot, the bandage being kept taut all the time. No injurious effects will follow if the cotton-wool has been carefully applied and the plaster bandage is kept quite flat and even. The bandage should then be carried from the outer side of the foot to the inner side of the leg well above the ankle, forming the first half of a figure-of-eight; then for a turn and a half round the leg. To complete the figure-of-eight, the bandage is carried from the outer side of the leg to the inner side of the foot. A turn and a half should now be taken round the foot at a higher point than the first turn, and so on as before till the whole foot and leg is covered in. Applying the bandage from without inwards is an important point first insisted on by Mr. Willett, as it helps materially to overcome the varus. This is well seen when the turn round the foot is completed, and the first half of the figure-of-eight has been made. It is then evident how the bandage pulls up the outer edge, so tending to abduct and evert the foot.

Another way of applying the plaster is to roll the bandage over the cotton-wool, beginning from above downwards till the leg and foot are covered in. The whole of the cotton-wool is thus enclosed by one layer of the plaster bandage. This layer must be firmly and evenly applied, as any rucking or slipping of the wool should the child struggle is thus prevented. The plaster bandage is next carried from the foot up the leg, enclosing the ankle and foot in figure-of-eight turns. On bringing the bandage again downwards towards the foot, slightly more pressure may be exerted in the proper direction for correcting the deformity. For a young infant a bandage six feet in length is usually sufficient; for an older child two bandages are generally required. For an infant the bandage is best about an inch and a half in width. The foot should be held in the corrected position till the plaster is set. There is a right and a wrong way even of doing this. The infant's

foot enclosed in the plaster should be held tenderly in the whole hand, taking care that the pressure is applied evenly and uniformly, and that the plaster is not pressed at any one spot inwards towards the foot, or that a constriction is not formed across the instep by the fingers. The leg should, of course, be steadied by the other hand grasping in the same tender manner the plaster bandage above the ankle. To facilitate rapid setting, and hence the saving of time, the plaster should be freshly burned, and the plaster bandage, if the surgeon is accustomed to its use, should be placed in hot water. The water in the containing vessel should just cover the bandage, and the bandage, placed

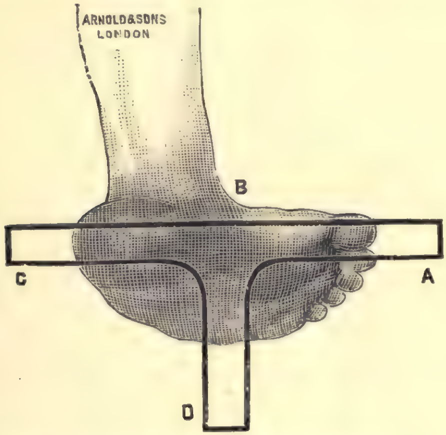



FIG. 95.—HAHN'S METHOD OF HOLDING THE FOOT DURING THE APPLICATION OF PLASTER BANDAGES. (After Bradford and Lovett.)

on end in the vessel, should remain there till air-bubbles rising from between its folds cease to escape.

The plaster bandage should be changed once a week at least, better twice a week. To remove the bandage, the end should be found, and it will then, if no loose plaster has been sprinkled over the bandage, be readily unwound. The sprinkling of loose plaster is quite unnecessary, and only adds to the labour of removal. On each occasion when the plaster is removed, the leg should be carefully 'massaged,' and passive movements of the ankle sedulously employed for a quarter of an hour or more.

Some hold the foot in position by an ordinary bandage passed round the base of the toes. In older children and adults this is useful, as they can pull the foot into position whilst the plaster is being applied and hold it so till the plaster is dry.

*Modifications of the Simple Plaster Method.*—The following modifications in applying the plaster bandage have been described. We have not used them ourselves, because we have found the simple method so efficacious that it seemed to us to leave nothing to be desired.

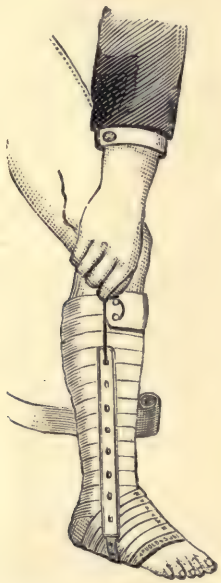


FIG. 96.—CHURCHILL'S METHOD OF APPLYING PLASTER BANDAGES.

*Hahn* uses a T-shaped splint of wood, which is placed on the foot as shown in Fig. 95 and enclosed in the plaster. The stem of the T (B D) is for correcting the varus, the cross-piece (C A) for overcoming the equinus.

*Churchill's Method.*—The faulty tendons are first divided, and the astragalus and other misplaced bones manipulated so as to stretch the ligaments and replace the foot in its normal position. A roller of Welsh flannel is then applied to the foot and leg, and

a circlet of webbing round the foot to protect the sole and give additional leverage power to the extension apparatus, which is fastened to the webbing. This consists of a strip of perforated tin bent at a right angle, the smaller arm being placed across the sole of the foot level with the metatarso-phalangeal joint, and the long or vertical arm carried up the leg on a level with the fibula. Two assistants fix the pelvis and thigh of the child, and draw upon a string attached to the upper end of the vertical arm of the tin. A plaster of Paris bandage is then applied from the toes upwards, each turn being made so as to raise and evert the foot and secure a purchase over the outer side of the perforated tin.

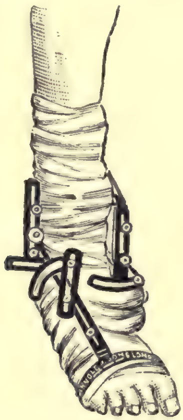


Fig. 97.—Apparatus, or 'Tractor Rectifier,' of Stillman for holding the Foot in the Improved Position whilst the Plaster dries. (After Bradford and Lovett.)

*J. Deschamps* encloses a wooden sole, to which is attached a cross-piece of wood, in the turns of the plaster bandage, and by the aid of this forces the foot into the corrected position and holds it so whilst the plaster is drying.

*Stillman* has invented the apparatus shown in Fig. 97 for holding the foot in the improved position whilst the plaster sets. It consists of 'articulating fenestrated steel rods with sector attachments, which can be secured at different angles' (Bradford and Lovett). In our experience there is no apparatus so suited for holding the foot whilst the plaster sets as the human hand.

With it the force can be regulated to a nicety, and the pressure made exactly in the wished-for direction. Patience only is required.

*Treatment by Silicate of Potash, Gum and Chalk, Dextrine and Starch.*—What has already been said of plaster of Paris applies so nearly to the above-mentioned materials that no detailed description of them is necessary. Plaster of Paris is, in our opinion, superior to them all, in that it sets more quickly, can be obtained everywhere, and is very cheap. It is true the silicate of potash can be made to set more quickly by the addition of magnesia, carbonate of calcium, etc., but this only entails further trouble, and in the end, as far as we can see, then possesses no advantage over plaster of Paris. It is a favourite application, however, with some surgeons.

### (3) *Poroplastic Felt, Gutta-percha, Leather, and Prepared Cardboard.*

*Treatment by Poroplastic Felt.*—This method, used alone, is only applicable to very slight cases, but may be of service for holding the foot in the restored position after forcible rectification, tenotomy, etc., for all of which purposes, however, we much prefer simple plaster of Paris.

Poroplastic felt was used by us somewhat extensively in the department some years ago as a substitute for plaster for overcoming *in slight cases* the varus position of the foot. Our only reason for giving up this treatment was that the shoes cost the parents a few shillings each, whilst the plaster cost them nothing, and was equally, if not more, effectual. The shoes we used were obtained properly modelled in various sizes from the manufactory of the late Mr. Cocking at Plymouth. When about to be applied, the felt shoe is softened in the steam-oven, and put on the foot and leg whilst hot and in the plastic state. The foot is then corrected as far as it will go without causing pain, and thus held till the felt has become cold and firm, which it will do in a few minutes. The poroplastic felt was applied by us next the skin, without the intervention of wool or bandages. Whilst plastic it can be moulded accurately to the shape of the foot in the corrected position, and thus holds it by diffused and uniform pressure

spread over the foot. Care must, of course, be taken not to apply it so hot as to burn the child. After the felt has become hard, it is secured to the limb by a few turns of a bandage, or by webbing, straps and buckles.

For the correction of the equinus after division of the tendo

FIG. 98.—POROPLASTIC FELT SHOE AS USED BY THE AUTHORS.

Achillis, we did not find the felt of much service, since the foot portion could not be bent on the leg portion to any extent without producing rucks over the front of the ankle, and such were of course fatal to its employment.

In place of our shoe, which consisted of one piece of felt open-

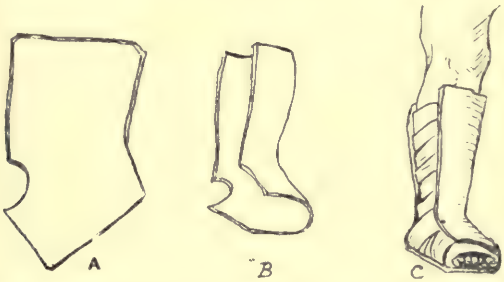



FIG. 99.—KÖNIG'S POROPLASTIC FELT APPARATUS. (After Hoffa.)
A, Pattern to which the sheet of felt should be cut; B, the felt moulded; C, the felt applied.

ing down the centre (Fig. 98), other surgeons apply the felt in a somewhat different manner. Thus, König places the shoe or splint on the inner side of the leg, and makes it himself out of a sheet of the poroplastic felt. The pattern (A) to which shape the felt should be cut, and the shoe when moulded (B) and when applied (C), are shown in the accompanying figures.

*Gutta-percha, Leather and Prepared Cardboard* have all been employed in a manner similar to poroplastic felt. The felt has

Fig. 100.—Adams' Method of overcoming the Varus Position of Club-foot by Means of a Simple Tinned-iron Splint and Bandage. (After Adams.)

obvious advantages over these materials, in that it is porous, and when hot is perfectly plastic, is more easy to work with

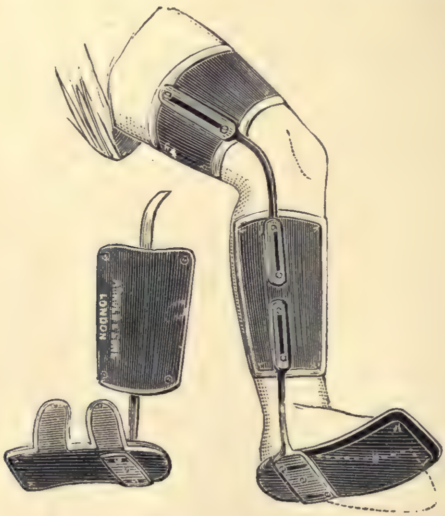



Fig. 101.—Beely's Splint for fixing the Foot and Leg after Correction. (After Hoffa.)

than gutta-percha, does not stick to the parts, and sets in a few minutes, retaining accurately the shape given it whilst plastic.

(4) *Combination of Splints with Bandages or Strips of Strapping.*

Under this head are included Adams' method of overcoming the varus by a simple straight iron splint and bandages, Sayre's method of correcting the equinus by a foot-splint and strapping, Beely's method of fixing the foot after rectification by an iron splint, and Bradford and Lovett's method of securing the foot and leg to a simple iron splint by adhesive strapping and bandages.

*Treatment by bandaging in Combination with a Simple Straight Splint (Adams' method of overcoming the varus position in infants).*—Mr. Adams, who is a stanch advocate when any ligamentous

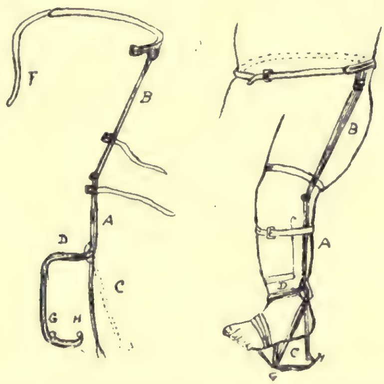



FIG. 102.—BRADFORD AND LOVETT'S APPARATUS FOR CORRECTING CLUB-FOOT.

rigidity exists for the complete eversion of the foot before attempting to overcome the equinus position, seeks to first correct the varus by bandaging the foot to a straight tinned-iron splint.

Having divided the tendons of the tibialis posticus and anticus, flexor longus digitorum, and, if necessary, the extensor longus hallucis, he bandages the foot to the splint in the deformed position for three or four days, till the punctures have healed. He then begins to evert the foot. The splint should reach above nearly to the knee, and extend a little below the foot. 'The best splints,' says Mr. Adams, 'are those made of tinned sheet-iron, well padded. The advantage of this material is that it can be bent a little outwards at the lower end as the foot is

becoming fully everted. First the foot and leg should be bandaged, and the splint being applied along the outer side of the leg, the bandage must be passed over the leg and splint from above downwards, so that a firm *lever* power may be established. Then the bandage should pass round the foot and draw it towards the lower end of the splint,' as shown in Fig. 100. The splint should be removed every other day in order that any undue pressure may be avoided. Except in severe cases, the eversion can be overcome in two or three weeks, or a little longer; but it is better, says Mr. Adams, that this stage should be delayed too

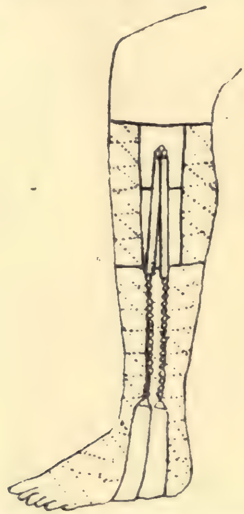


FIG. 103.—BARWELL'S METHOD OF CORRECTING CLUB-FOOT BY ELASTIC TRACTION. (After Barwell.)

long, than that the second stage, or the correction of the equinus, should be commenced too soon. We have frequently employed Mr. Adams' method, and have found it admirable for private cases where the splint could be adjusted by ourselves; but for out-patient work, where the patient is only seen once or twice a week, it is apt to produce sores. Hence we prefer for out-patients the plaster method. In using Adams' splint, we have found it better to apply it daily, and alternately to the inner and outer side of the leg. One advantage, as it seems to us, in

the use of this splint is that the varus is not too quickly overcome, and we believe that in the infant the good effect of thus slowly correcting the varus is not so much that the ligaments are stretched as that the soft and pliable bones are gradually moulded towards their normal shape. Relapses have certainly been less common with us when the varus has been thus slowly overcome than when it has been at once reduced by the division of the ligaments on the inner side of the foot. When the latter operation is performed, the scaphoid and the bones in front of it can be shifted on the head of the astragalus, as later pointed out; but the bone deformity, the inbent astragaloid neck, and

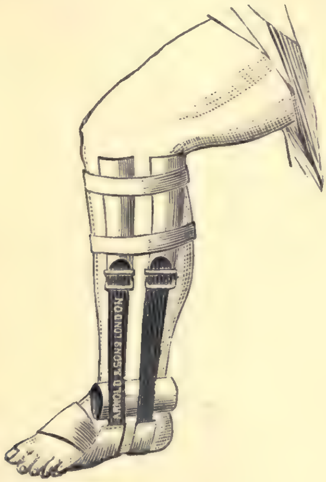


FIG. 104.—ANDREWS' ELASTIC TRACTION APPARATUS. (After Rédard.)

the bowing in its long axis of the os calcis, remain untouched.

*Sayre's Method of correcting the Equinus Position by Means of a Foot-splint and Adhesive Strapping.* — The foot-splint consists of a thin piece of board the length of the foot; a strip of diachylon plaster, the same width as the board, is wound round it lengthways, first along its upper surface, then round the posterior end, and back again along the under surface to the anterior end, leaving a free portion of strapping long enough to reach up the leg as far

as the knee. Tenotomy having been performed and the deformity corrected, the foot is firmly secured to the foot-piece, and the correction maintained by fixing the free end of the strapping to the front of the leg by a roller bandage. The upper end of the strapping, adhesive surface outward, is turned down over the upper turns of the roller bandage, and then covered by a few more turns of the roller to prevent slipping. A second strip of diachylon, applied to the outer side of the foot-piece and leg, can be further used for counteracting any tendency there may be for the foot to turn into the varus position.

*Beely's Apparatus* (Fig. 101) consists of a properly-padded metal thigh-trough, leg-trough, and foot-piece united to each

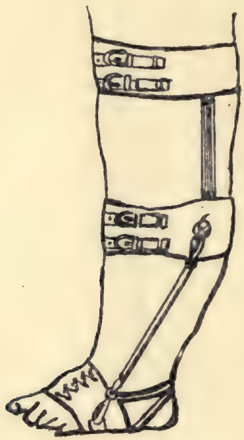


FIG. 105.—LEWIS W. MARSHALL'S APPARATUS.

other by an outside firm, but at the same time bendable, steel rod. The foot-piece is shaped to the sole, and on its inner side are two vertical tongues for taking hold of the inner border of the foot. The sole-plate is fixed to the outside steel rod by screws, so that it can be rotated outwards or inwards to the desired extent.

The chief point about the splint is that the thigh-piece is fixed at an angle with the leg-piece by a proper bend in the steel connecting rod. 'It is only,' says Beely, 'by this means that the

secure and permanent outward rotation of the foot can be effected.' In using the splint, the foot is first forcibly rectified by the hands, and the splint, so bent as to correspond to the amount of improvement gained, is secured in this position by a flannel bandage to the leg and foot. The foot and leg should be previously encased in a flannel or domett bandage.

*Bradford and Lovett's Apparatus* (Fig. 102) consists of two steel strips connected by a free joint at the knee. The upper end of the thigh-piece is connected with a bent piece of tempered steel long enough to encircle half the patient's pelvis, a leather strap completing the circle. The lower end of the calf-piece is bent so as to pass under the foot, and has two buckles, G and H, to receive adhesive plaster on the patient's leg, used for the purpose of keeping the heel well in the appliance. A cross steel

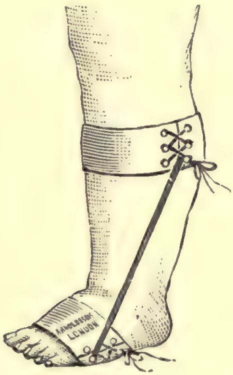


FIG. 106.—WILLARD'S APPARATUS. (After Rédard.)

strip, D, passes in front of the leg above the ankle, and with a strap which goes behind holds the leg from slipping forward or backward. A steel rod, C, projects to the outer side of the foot. It should be strong enough to stand ordinary strain, but soft-tempered and capable of being bent by a wrench. It furnishes the point from which a pull upon the deformity can be made. The pull upon the foot is effected by means of a strip or strips of adhesive plaster wound about the foot at the level of the ball of the toes, the free end being long enough to reach the end of the arm C, to which it is fixed. The advantages claimed for this splint

are that it is cheap, light, can be used by the mother or nurse, makes no pressure on the dorsum of the foot to cause pain or sloughs, firmly holds the limb, and the child cannot kick it off.

(5) *Elastic Tension by Means of Indiarubber Accumulators.*

This method is highly recommended by some surgeons, notably by Mr. Barwell, Dr. Sayre, and Dr. Lewis Marshall, of the Children's Hospital at Nottingham. The principle consists in

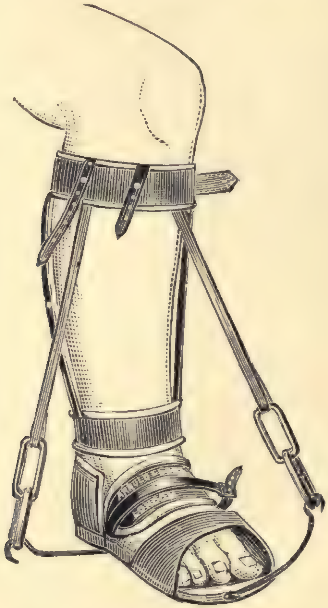


FIG. 107.—BLANC'S APPARATUS. (After Rédard.)

applying continuously to the foot elastic tension in a direction opposite to that of the deformity.

*Barwell's Method.* — Barwell uses strapping plaster, rubber accumulators, and strips of tin. The strapping is so fixed to the foot as to have a broad base of pull. The leg is properly bandaged, and tin strips fixed along the leg vertically. From the top of the tin strip the accumulator takes its *point d'appui*. The

lower end of the accumulator is fixed in a suitable manner by a chain or strap to the free end of the strapping embracing the foot. The apparatus, when rigged up, is so arranged that the force of the accumulator takes as nearly as possible the place of the tendon it is wished to supplement (Fig. 103).

We have used Mr. Barwell's method for in-patients, and have found it successful. Much care and attention, however, are required in nicely adjusting the plates of tin, the strapping, and the rubber bands, and frequent reapplications are found necessary.

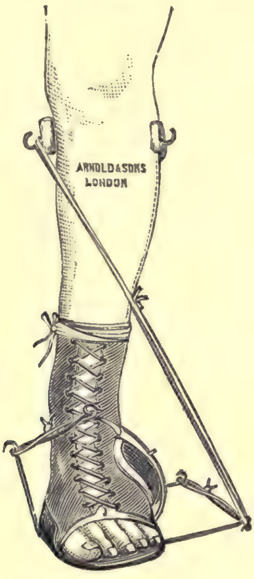



FIG. 108.—TRÉLAT'S APPARATUS. (After Rédard.)

*Dr. Sayre* employs apparatus similar to that of Mr. Barwell.

*Dr. Andrews*, of Chicago, also uses apparatus like that of Barwell, but simpler in construction. It will be understood by reference to Fig. 104, p. 157.

*Dr. Lewis Marshall*, of the Children's Hospital, Nottingham, has used with much success the apparatus shown in Fig. 105, p. 158. It consists of a modified leather slipper, with a metal sole-plate arranged to cover the anterior half of the foot, of a padded leather circlet for the calf, and a similar one for the

thigh, the two latter being held together by lateral straps. The thigh circlet, the object of which is to prevent the calf circlet slipping, can be further secured by lateral rings and elastic webbing to the infant's binder or stays, and in older children by a very loose waistband of soft leather, and shoulder-straps of the same material, which are united across the chest and shoulder-blades by a strip of elastic webbing to prevent slipping from the shoulders whilst at the same time no pressure is made. From the outer and front angle of the metal plate forming the sole of the slipper, a rubber accumulator is carried to the calf-piece, and keeps up a continuous elastic pull on the foot in the direction of dorsal flexion and eversion. We have used this for in-patients, and can speak well of it; but in our opinion for out-patients it is open to the same objections that we hold apply to all forms of apparatus requiring attention on the part of the mother.

Dr. Marshall uses this apparatus after division of the tendo Achillis, which he recommends quite early in the treatment.

*Dr. Willard* uses an apparatus similar to that of Dr. Marshall (Fig. 106).

*Blanc and Trélat* use more elaborate means of applying elastic traction (Figs. 107, 108). A detailed description is not necessary. Their methods amount to the application of elastic traction to the Scarpa's shoe.

(6) *Mechanical Apparatus in which the Correcting Force is applied by Traction, or Pressure by Means of Cogwheels, Screws, Springs, Levers, etc.*

The mechanical apparatus described under this head may be said to consist (1) of some form of foot-piece or shoe for holding the foot; (2) of a leg-piece or circlet variously fixed to the leg, or leg and thigh, by straps, buckles, etc.; and (3) of a leg-iron or spring. These portions are so connected together as to bring pressure or traction to bear on the foot in a direction, so to speak, opposite to that of the deformity. The movements of the foot-piece on the leg-portion are carried out by means of variously disposed cogwheels, springs, etc. In most of them the foot and leg is placed in the apparatus in the deformed position, with or without a previous tenotomy or other operative measure, and

having been secured by variously arranged bandages and straps, the cogwheels, or other like contrivances, are turned, generally by means of keys, so as to draw or force the foot towards the normal position. The correction of the deformity by this form of apparatus can only be brought about gradually; if attempts are made to restore the foot to its normal position too quickly, one of two things will happen: either the foot will partially escape from the instrument through the yielding of the bandages or straps, or if the foot is held in the apparatus, pressure sores will be produced, and the apparatus must be left off till these have healed. On each application of the apparatus it has been a general rule with orthopædic surgeons to turn the cogwheels or screws, etc., till the force exercised causes the patient an uncomfortable sensation of too great pressure, or slight pain, and then to reverse the screw little by little, say a quarter or half a turn of the key, till this discomfort is no longer felt. The objections to all forms of mechanical apparatus of the kind under consideration are: the trouble of fixing the foot and leg properly in it; the liability of all straps and bandages to stretch and slip; the unequal or band pressure which is necessarily exerted by straps or bandages, and hence the risk of sores; the liability of the apparatus to get out of order; and lastly the expense. The apparatus may be used alone, or combined with manipulation, forcible correction, tenotomy, or syndesmotomy. It is only in very slight cases that it should be employed as the sole agent. We do not wish to say that moderately severe cases cannot be cured by its means alone, but for it to be effectual so much time and attention are required, and consequently the trouble and expense to the patient are so great, that we cannot recommend it. Indeed, in the Orthopædic Department, we have now for many years entirely abandoned the use of all apparatus for the correction of congenital talipes varus, and employ plaster of Paris in its stead. The advantages that we, amongst others, claim for plaster over cog-wheel or other complicated apparatus are stated under our description of the plaster method (p. 146).

Mechanical apparatus for the treatment of congenital club-foot has been employed for a great number of years. The primitive forms of it used by Sheldrake, Vernel and others in the early part of the century have been brought to great perfection in recent

times. The earlier improvements were due to the labours of Scarpa, Stromeyer, Little and Tamplin. Later improvements have been made by Adams, Sayre, Taylor, Bradford, Shaffer, Reeves, Garibaldi, and others. Indeed, nearly every surgeon interested in orthopædics may be said to have invented some form of apparatus for the cure of club-foot, or to have more or less modified, and in some instances improved, that already in use. The basis of most of the mechanical apparatus will be found to practically consist in the adoption of the mechanical principles of the old Scarpa's shoe. This in former times was very extensively used, and as modified by Little, Tamplin and Adams is, perhaps, the best-known form of apparatus in this country. Further additions have been made to the apparatus both here and on the continent of Europe, and in the United

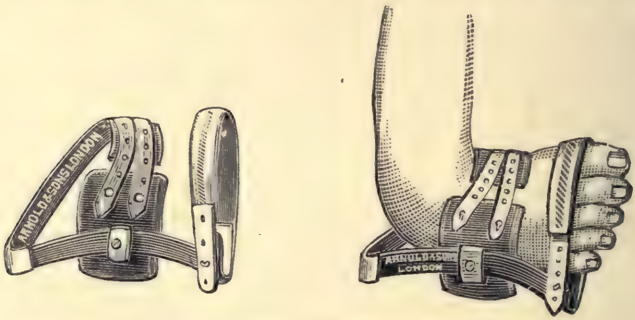


FIG. 109.—SCARPA'S VARUS APPARATUS.

States. The apparatus as a general rule may be said to be so constructed as to bring pressure or traction to bear in three directions: (1) To abduct or evert the fore part of the foot; (2) to rotate the foot outwards on its antero-posterior axis; and (3) to dorsal-flex the foot at the ankle-joint—that is, to overcome the equinus.

A brief description, with illustrations, is given of some of the chief forms of apparatus that have been and are still used by some surgeons.

*Scarpa's Apparatus.*—Scarpa divided the treatment of club-foot into two stages. For the first stage, or that of the correction of the varus, he employed the apparatus shown in Fig. 109. For the second stage, *i.e.*, the correction of the equinus, he used

the shoe (Fig. 110) which has since gone by his name. The horizontal steel spring shown along the outer side is intended to

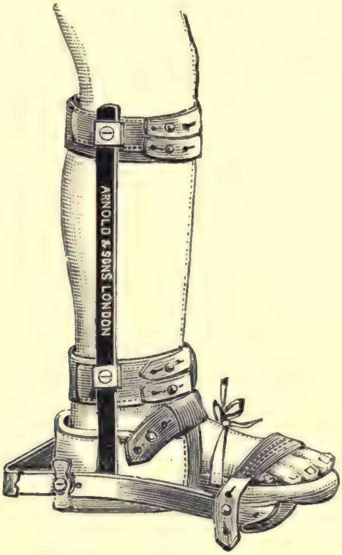



FIG. 110.—SCARPA'S SHOE.

retain the foot in line with the tibia. Scarpa's original instruments are no longer used, but the term 'Scarpa's shoe' is now

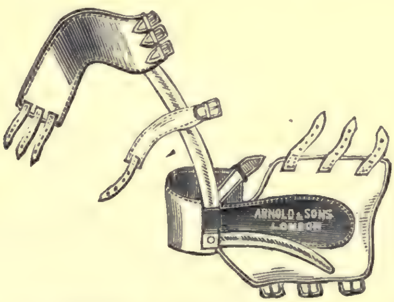



FIG. 111.—STROMEYER'S MODIFICATION OF SCARPA'S SHOE.

often loosely applied to the modifications of it which are still employed by some surgeons.

*Stromeyer's Apparatus.*—Stromeyer improved Scarpa's shoe, and added a lacing piece to secure the fore part of the foot to the horizontal spring (Fig. 111). For the cure of the equinus he employed the well-known foot-board which goes by his name (Fig. 112). Both of these are now practically obsolete.

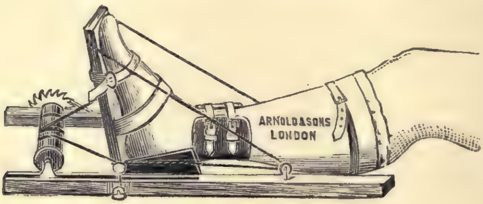



FIG. 112.—STROMEYER'S FOOT-BOARD.

*Little's Modification of Scarpa's Shoe.*—Little's instrument consists of an iron shoe covered with leather and well padded with horsehair; of a steel spring with its concavity outwards, which

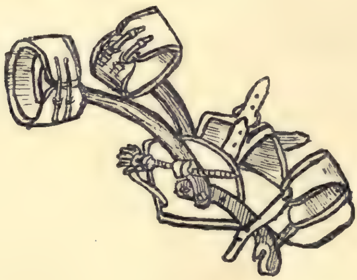


FIG. 113 —LITTLE'S MODIFICATION OF SCARPA'S SHOE.

by means of a padded strap is worn on the outer side of the leg; of a strap and bandage, which go round the ankle and hold the heel and foot securely in the shoe; and of a short spring, which draws the front of the foot and the toes outwards by means

of a padded strap passed round them. The male screw by passing through the female screw, which itself is fixed by a rotatory rivet to the leg-spring, acts upon the ankle-joint

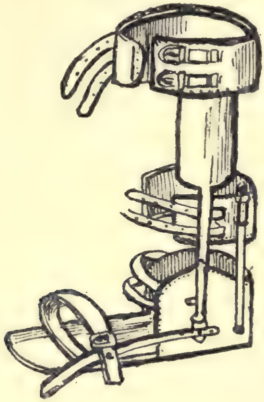


FIG. 114.—TAMPLIN'S MODIFICATION OF SCARPA'S SHOE.

and is used to overcome the equinus. The chief alterations instituted by Little lay in a different adaptation of the screw

FIG. 115.—ADAMS' SCARPA SHOE FOR OVERCOMING EQUINUS.

that acts upon the ankle-joint and in the arrangement of the straps.

In *Tamplin's apparatus* the eversion of the anterior part of the

foot is also overcome by a horizontal steel spring attached to the outer side of the foot-piece. A rigid leg-iron with a padded side-plate at its upper part is substituted for the leg-spring, and is moved at the ankle-joint by a cogwheel in place of Little's male and female screw. A second cogwheel below the first is employed for helping in the eversion of the foot. Little's ankle circlet, but with two straps instead of one, is employed to hold the heel down (Fig. 114).

*Adams' Apparatus.*—Mr. Adams employs several modifications of the above described 'Scarpa's' shoes. In Fig. 115 Tamplin's shoe

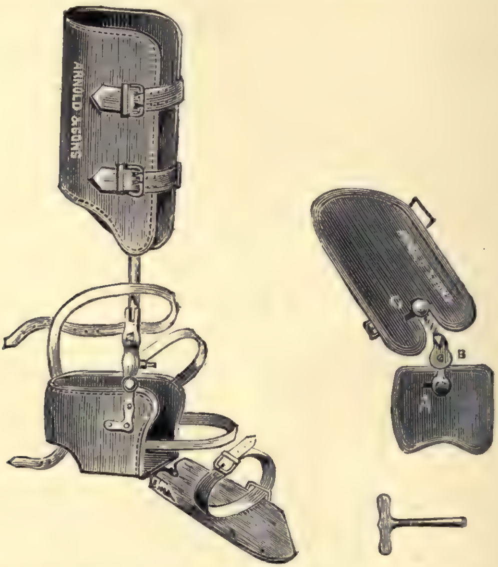



FIG. 116.—ADAMS' SHOE FOR CORRECTING THE EQUINUS WHERE SOME VARUS REMAINS.

is modified as follows: The ankle-circlet and straps are dispensed with as useless; the heel-plate is diminished in size; the heel-strap passes through an aperture in the heel-plate and sole instead of across the front of the heel-plate. A straight horizontal bar is substituted for the spring; a single cogwheel acting in the direction of flexion and extension is alone employed for overcoming the equinus. This instrument is used by Mr.

Adams after the varus position has been cured, and for pure equinus.

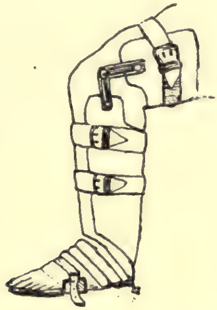


FIG. 117.—ADAMS' INFANTILE VARUS SPLINT.

In Fig. 116 Tamplin's shoe is still further modified by having the sole-piece divided transversely at a spot corresponding to the

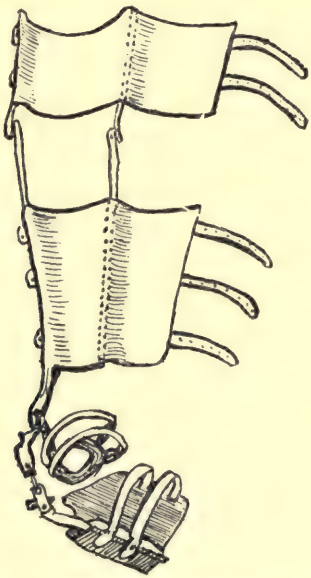


FIG. 118.—ADAMS' APPARATUS FOR ADULT VARUS.

transverse tarsal joint. The fore part of the sole-piece is moved by means of cogwheels A, B, C in various directions. The calf-plate

at the upper part of the leg-iron is better adapted to the calf. This apparatus is used by Mr. Adams where there is some inward inclination of the foot as well as equinus. The chief improvement consists in placing additional cogwheels opposite the anatomical centre of motion in the sole.

For *infantile varus* Mr. Adams employs the 'varus splint' shown in Fig. 117. It consists of a thigh-trough, leg-trough, and a foot-piece. The thigh and leg troughs are united by a free joint at the knee, and are fixed to the limb by straps. A single cogwheel placed behind the heel moves the foot-piece on the calf-piece in the direction of flexion and extension. A rectangular

FIG. 119.—REEVES' APPARATUS OR SCARPA'S SHOE.

steel bar set off about three-fourths of an inch is attached to the outer margin of the sole-plate, and retains the fore part of the foot by means of a webbing strap and buckle in the everted position. This apparatus is used to overcome the equinus, the varus having been already corrected by the straight tin splint described at p. 155. We have used this splint frequently both in private and for hospital in-patients, and found it answer admirably. It is light and simple in construction, and has the great advantage that it is carried above the knee, thus securing a firmer hold on the infant's limb.

For *adult varus* Mr. Adams uses the apparatus shown in

Fig. 118. It consists of a thigh-trough, a leg-trough, a heel-piece, and sole-plate. The heel-piece is composed of two pieces of steel arranged in elliptical form, depressed on the outer side and rising nearly to the inner malleolus on the inside. This is connected with the short bent rectangular lever, in which a cogwheel is so cut that it may be controlled by the movements of the latter. The sole-plate is accurately adapted to the inclination of the sole. The apparatus is worked by three cogwheels. One corresponds to the ankle-joint, and is used to overcome the equinus; a second

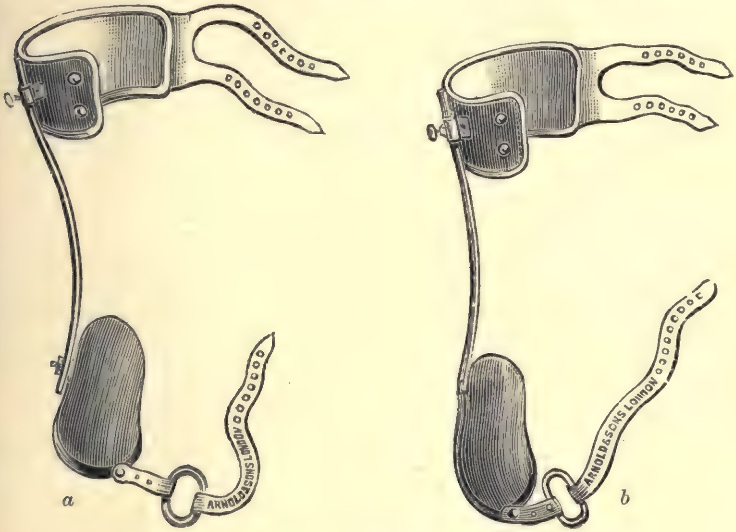



FIG. 120.—GARIBALDI'S APPARATUS. (After Rédard.)
(*a*) When free. (*b*) When applied.

corresponds to the transverse tarsal joint, and is used to correct the inversion; the third also corresponds to the transverse tarsal joint, and is used to lift up the outer border of the foot.

*Reeves' Scarpa's Shoe* (Fig. 119).—The shoe is smaller than the majority of Scarpa's shoes and is fixed on by a toe-bandage or strap, and across the instep by a shaped leather piece. The outside leg-iron is secured to the calf by a lacing-piece shaped to the part.

*Garibaldi's Apparatus.*—This apparatus is practically a much-simplified Scarpa's shoe. It consists of an outside steel leg-spring, a simple wooden sole-plate, and a calf-circlet. The calf-circlet moves up and down the leg-spring in a sliding groove provided with a screw-nut so as to regulate to the length of the leg. The steel spring is fixed below to the foot-piece by means of a simple screw allowing of flexion and extension. The foot, previously protected by soft flannel, is secured to the foot-piece by a bandage. The spring is then strapped to the leg by the calf-circlet, and by its action lowers the inner border of the foot. The strap attached to the front of the foot-piece passes obliquely outwards and upwards, to be fastened by a button to the external part of the calf-circlet. An indiarubber ring intercalated continues the elastic tension. The apparatus should draw the foot into a position of dorsal flexion, abduction, and rotation outwards (Fig. 120).

3. **The Operative Treatment of Club-foot.**—It is only in recent times, indeed since the introduction of subcutaneous tenotomy by Stromeyer and Little, that the operative treatment of club-foot has become general. Formerly, as already mentioned, mechanical treatment was alone resorted to for the cure of the deformity. Now, however, some form of operation is nearly always, except in slight cases, combined with the mechanical correction.

The introduction of tenotomy gave a great impetus to the treatment of club-foot, and exaggerated statements were no doubt made that, with the aid of tenotomy and mechanical apparatus, even the most severe and intractable cases of the deformity could in this way be cured. The majority of surgeons, however, now hold, and with them the authors fully agree, that severe and intractable cases are met with in which tenotomies and mechanical treatment are not alone sufficient.

Hence it is the practice of some, where there is much ligamentous rigidity, to divide the ligaments that hold the foot in the deformed position, as well as the tendons, an operation which may be done subcutaneously, or through an open incision. Other surgeons in intractable cases, or for the purpose of expediting the cure in slighter ones, wrench the foot into the natural position, tearing through contracted ligaments and other

resisting structures, and in some instances fracturing the bones. Others, again, in intractable cases, cut through the tarsus or remove certain bones or portions of bones therefrom. These various methods will be considered under the heads of—1. Forcible rectification, or 'redressement forcé.' 2. Tenotomy, or the division of tendons. 3. Syndesmotomy, or the division of ligaments. 4. Subcutaneous division of all resisting soft tissues on the inner side of the sole of the foot (*Buchanan's operation*). 5. Subcutaneous division of all the resisting soft tissues in the sole, and behind the inner ankle (*Lane's operation*). 6. Open division of all resisting soft structures through an incision on the inner side of the foot (*Phelps' operation*). 7. Section or excision of bones. Under this head is included tarsotomy, or division of the tarsal bones; and tarsectomy, or the excision of one or more, or portions of one or more, of the tarsal bones. 8. A combination of division of the tarsal bones with crushing (*Fitzgerald's operation*).

(1) **Forcible Rectification.**—Forcible rectification of the foot, the 'redressement forcé' of the French, has the approval of many well-known orthopædic surgeons. It consists in wrenching the foot into a corrected position, either at once or at intervals, varying from a week to a month, and retaining it in this position by plaster of Paris or other apparatus. An anæsthetic should always be given, and a previous tenotomy or syndesmotomy is generally advisable. Some surgeons, as a preliminary, perform Phelps' open incision of the soft tissues on the inner side of the foot.

Forcible rectification may be done (1) with the hands—*forcible manual rectification;* or (2) by the aid of apparatus—*forcible instrumental rectification.*

(1) *Forcible manual rectification* consists in wrenching the foot into the best possible position, and retaining it in this position between the wrenchings, which should be done at intervals, varying from a week to a month, in plaster of Paris or other apparatus. It has been especially advocated by Delore, Hueter, Wolff, Bradford, and König, amongst others.

*Method of Operating.*—The patient having been placed under an anæsthetic, the foot is held over the end of a firm table, and the surgeon, grasping the foot in one hand and the leg in the

other, wrenches the foot towards the position of abduction and dorsiflexion, at the same time circumducting it and moving it laterally from side to side. In the case of the adult and older children, the leg should be held firmly by an assistant, whilst the surgeon uses both hands to wrench the foot. In the infant and child care should be taken not to use sufficient force to cause separation of the lower epiphysis of the tibia or fibula. The rectification is aided by a preliminary tenotomy of the tibial tendons and tendo Achillis, and in suitable cases by division of the astragalo-scaphoid capsule, plantar fascia, and other resisting bands. It is advised by Rédard* that the wrenching and manipulation should be continued for half an hour to three-quarters of an hour at each sitting. We do not ourselves quite see what is gained by taking so long a time. Our own plan, when we resort to this method, has been after the division, say, of the tibial tendons or of the astragalo-scaphoid capsule, to force the foot as far as it will go without using any excessive violence towards the position of abduction, then freely to circumduct at the subastragaloid joint, and to repeat the procedure two or three times. The foot is next placed in plaster of Paris in the improved position, and a second wrenching generally undertaken at the end of a week or a fortnight. When the varus has been well overcome, say in from six weeks to two months, according to the severity of the case, the tendo Achillis is divided and the foot forcibly wrenched in a direction of dorsiflexion. The foot is again circumducted and manipulated in various directions, and then forcibly dorsiflexed; and after these movements have been repeated several times the foot and ankle are once more secured in the best position obtainable in plaster of Paris. When the plaster is removed preliminary to each sitting for forcible rectification, the limb should be thoroughly massaged, and passive movements practised for half an hour or so at the various articulations. In this way the healthy nutrition of the muscles and the functions of the joints are promoted and improved.

(2) *Forcible Instrumental Rectification.*—The desire of surgeons for more power in the stretching of the contracted ligaments, and a better hold of the bones than can be obtained by the hands, has

* Rédard, *op. cit.*

led to the invention of various machines for the forcible correction of the foot. Some of these, as Thomas's wrench and Bradford's lever, are fairly simple contrivances. Others, as Phelps', Grattan's, and Rédard's apparatus, are elaborate and complicated machines. The patient having been anæsthetized, and a preliminary tenotomy or syndesmotomy having been done, either at the time of the operation or some days previously, the foot is placed in the apparatus and forcibly wrenched into the over-corrected position. The force should be gradually rather than suddenly applied. In slight cases the conversion of the varus into valgus, and the equinus into a position of dorsiflexion, it is said, is always possible, and can be obtained at once. In severe cases over-correction cannot be always gained at one sitting, and the force in such should only be gradually brought to its maximum, and after some minutes. The foot should be then secured in the improved position in plaster or other apparatus. The amount of force that can be applied safely is apparently very great, and, as far as we know, no serious accident has attended the method; at least, we are not aware that any such cases have been published. Sloughs, however, it would seem, are apt to occur, and such, to say the least, are most undesirable, as they invariably delay the cure of the deformity.

As all are aware, the use of the osteoclast in the correction of such deformities as knock-knee and bow-legs is rarely attended with lesions of the skin, and it is said that there is no more risk in the use of apparatus in the immediate forcible correction of club-foot than there is in knock-knee or bow-legs. The cases, however, do not seem to be analogous. In the one class of cases the osteoclast is applied to a bone in its continuity; in the other to several bones united by various ligaments and articulating with each other by variously-shaped joints. *A priori*, we should imagine that the severe violence required to correct the deformity—the bruising of the skin, the ruthless tearing apart of the articular surfaces, the rending of ligaments, and crushing and breaking of the bones—must be at least attended with some risk, even though no permanent damage to the delicate mechanism of the foot were the result. We confess that the operation of immediate correction strikes us not only as unnecessarily severe, but as lacking in the scientific principles which

should guide us in our endeavours to cure the deformity. In the infant, we hold, so violent a procedure can seldom be necessary; for severe cases in older children, there appears something to be said in its favour. But even for such cases it seems to us to be defective in that precision that can be brought to bear on the case

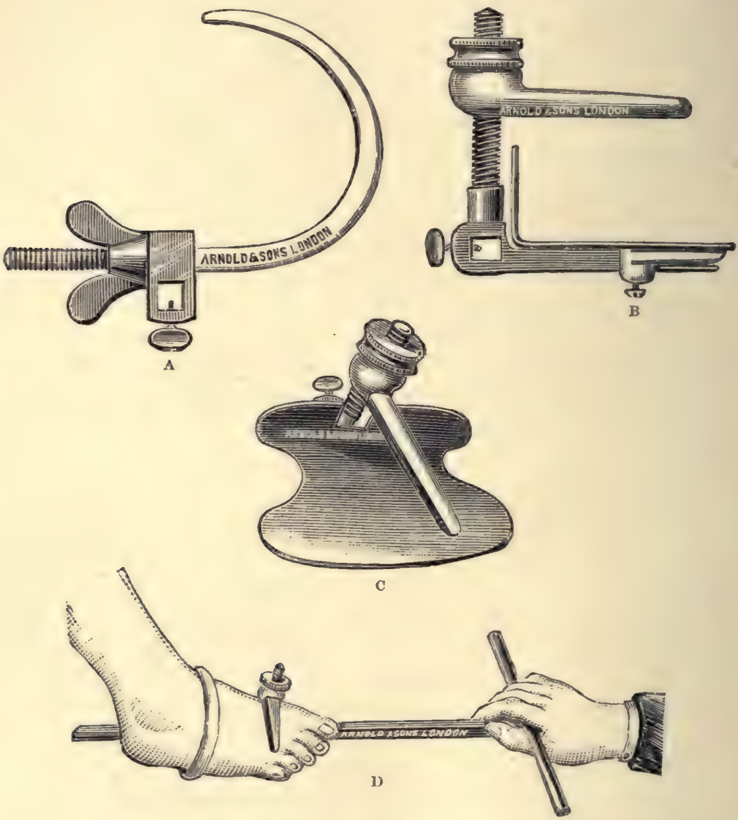



Fig. 121.—Bradford's Lever. (After Bradford and Lovett.)

in the performance of a well-planned tarsectomy. We have not had, as yet, much practical experience of the operation, and therefore withhold our judgment, merely stating such theoretical objections as occur to us. The operation is said to expedite the cure. This is, no doubt, an obvious advantage, and one we should

certainly avail ourselves of, if celerity of cure be not obtained at too great a risk, and the cure, as it is called, give an equally good foot as that which follows less violent measures. At present we think we are hardly in a position to judge of the ultimate results. The foot thus treated is said to be, more or less, completely restored

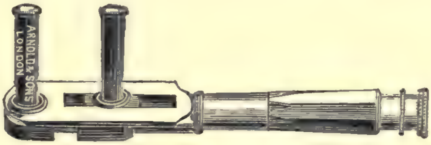



FIG. 122.—THOMAS'S WRENCH FOR CLUB-FOOT.

to its normal symmetry and functions at the end of the treatment, and a few cases have been reported in which it is said that after some years there has been no relapse.

Some surgeons, as M. Rédard, do not attempt to correct the

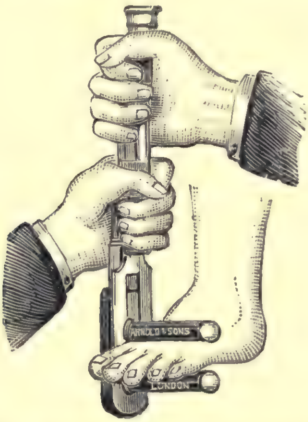



FIG. 123.—THOMAS'S WRENCH FOR CLUB-FOOT APPLIED. (After Rédard.)

deformity at one sitting, but rather aim at stretching the ligaments and moulding the articular surfaces of the bones. They condemn the use of excessive force, and although they do not object to the rupturing of the ligaments, they avoid fracture of the bones.

This method appears to us far preferable to that of immediate rectification, and as likely to do less harm. We have employed Rédard's and Grattan's osteoclast in a few cases, but we have so far not been very satisfied with the results.

A short description of some of the chief appliances that have been invented, and the methods of using them, follows.

*Bradford's Lever* (Fig. 121).—' A steel bar (*d*) is applied to the inner side of the foot long enough to give sufficient leverage for efficient force. A curved half-circle of steel (*a*) can be slipped on to this bar, and by screw force made to press on the upper and outer side of the astragalus. The front of the foot rests

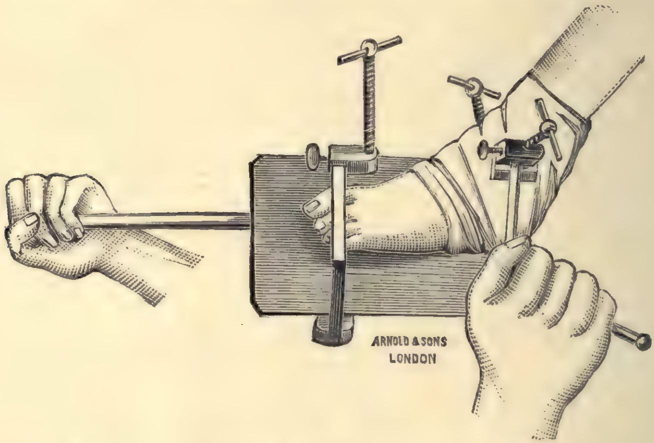



FIG. 124.—BRADFORD'S TARSOCLAST OR SCREW-WRENCH.

on a sole-plate (*c*), which presses on the inner side, and extends on the sole to the proximal end of the cuboid, but not to the os calcis. This sole-plate is also slipped upon the bar, and a short steel arm (*b*) adjustable by a screw, exerts pressure on the top of the foot. If the screws are sufficiently tightened the foot will be held securely as in a vice, and by moving the lever-bar the front of the foot can be twisted outwards and upwards, the astragalus being the fulcrum on which the force is applied.'

*Thomas's Lever or Wrench.*—The late Mr. O: H. Thomas, of Liverpool, used an apparatus somewhat resembling a Lowel's wrench (Fig. 122) which he applied as shown in Fig. 123. The

bars of the wrench are approximated by a screw in the handle, after the manner of the ordinary screw-wrench, and are covered with vulcanite to protect the skin. M. Rédard states that he has found this lever of service in infants,* but that with it there cannot be developed much force.

*Bradford's Tarsoclast or Screw-Wrench* (Fig. 124). — This apparatus is designed to apply pressure in three directions by means of screws, and at the same time enable the surgeon to curve and twist the front of the foot. It is used by Dr. Bradford for obstinate cases only, in which after tenotomy and syndesmotomy correction with the hands cannot be completely brought about.

*Morton's Club-foot Stretcher.*—Dr. Morton, of Philadelphia, uses

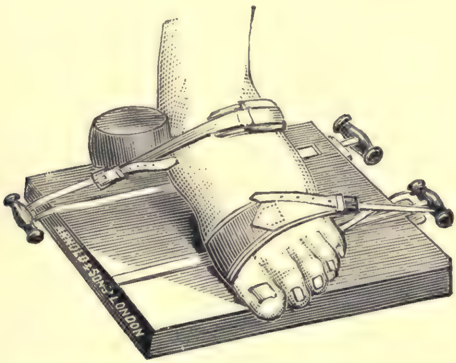


Fig. 125.—Morton's Apparatus for rectifying the Foot.

the apparatus shown in the accompanying illustration (Fig. 125). The straps, however, are said to be liable to stretch and slip, and the apparatus consequently to lack in precision. It would appear to us as likely to do less damage, and cause less bruising of the skin, than the rigid forms of apparatus.

*Phelps' Machine for correcting Club-foot* will be best understood by looking at the accompanying drawings. It consists of a leg-board, to which are attached two levers, one for holding the heel firmly and making pressure on it, the other for acting upon the anterior part of the foot. The leg in the flexed position is secured

* Rédard, *op. cit.*, p. 692.

to the leg-board by straps, and prevented from slipping by a suitably-arranged sliding-piece above the knee. The anterior part of the foot is ingeniously secured to the long foot-lever by straps, which can be adjusted and tightened by means of the pressure screws. When all is ready, the surgeon works the foot-lever, thus flexing and abducting the foot, while the assistant makes counter-pressure with the second lever on the heel. The instrument is complicated, and somewhat difficult, it is said, to

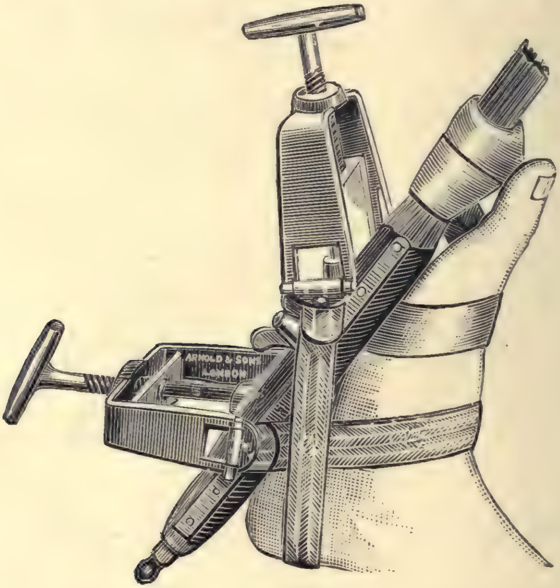



FIG. 126.—PHELPS' MACHINE FOR THE FORCIBLE CORRECTION OF CLUB-FOOT.

adjust. We have no practical experience of it ourselves, but M. Rédard considers it an excellent contrivance.

*Rédard's Apparatus for the Forcible Correction of Club-foot* consists of a firm base-board (Fig. 128) that can be securely fixed to a table or stool. To this base-board are attached two well-padded, slightly concave metallic pressure-plates—one for the heel, and one for the fore part of the foot. A long metal lever, working on a pivot-fulcrum near the anterior part of the base-board, has attached to its short arm a third pressure-plate, also

well padded, adjustable to the foot over the calcaneo-cuboid joint by suitable screws. The patient lying on the operating-table, with his leg hanging vertically over the end, the foot is placed flat on the base-board (which is supported on a small table or stool of suitable height), between the two pressure-plates on the inner side, and the lever pressure-plate on the outer. When the instrument has been properly adjusted, the lever is slowly moved; and, to obtain a sustained and powerful

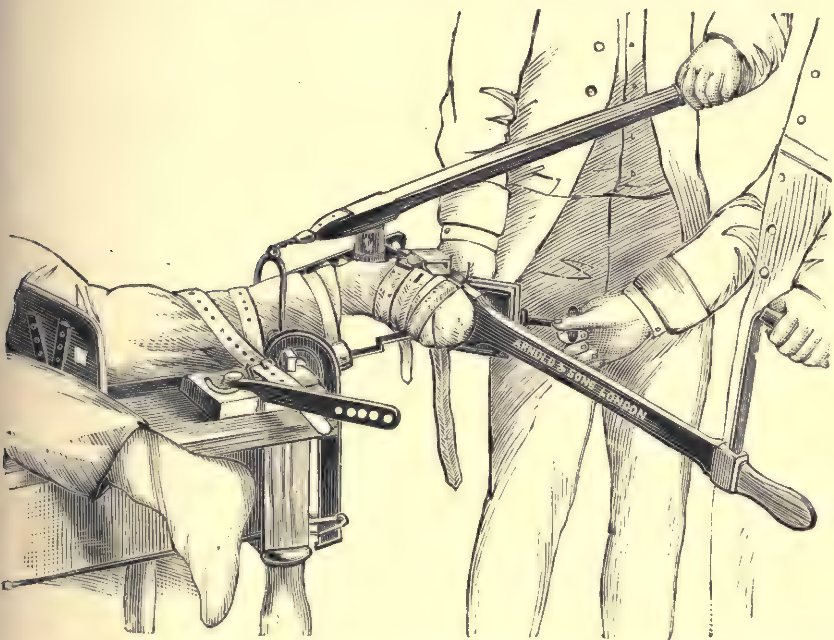



FIG. 127.—PHELPS' MACHINE FOR THE FORCIBLE CORRECTION OF CLUB-FOOT.

action, a strong rubber cord is wound round the long arm of the lever, and over a suitably shaped hook attached to an anterior corner of the base-board. The elastic cord is gradually tightened, thus increasing the force till the foot is brought into, or as near as possible into, the corrected position. The equinus is then overcome by raising the anterior end of the board, the foot being still retained between the pressure-plates, and the leg held in

position. The apparatus can be rapidly adjusted for either right or left foot.

If preliminary tenotomies appear necessary, M. Rédard does not resort to his instrument till some days have elapsed. In its use, he insists that the force should be applied slowly, not in the manner of an osteoclast. He endeavours to stretch, or if necessary to rupture, the ligaments, and so gradually mobilize the articulations, but to avoid fracturing the bones. Further he advises that the rectification should not be accomplished at one sitting. He states that no inflammation or accident of any kind has followed.

*Grattan's Method of Forcible Rectification.*—Dr. Grattan uses the osteoclast he invented for the treatment of knock-knee and

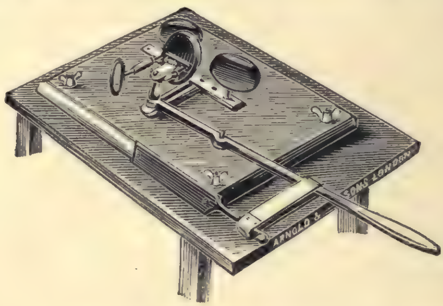



FIG. 128.—RÉDARD'S APPARATUS FOR THE FORCIBLE CORRECTION OF CLUB-FOOT.

bow-legs for intractable cases of club-foot. He says,* ' I find this instrument very precise and accurate . . . and as now improved I can crush or tear any foot in any way I please. It is used in the following manner : By means of the side screws the opposing bars are fixed at the desired distance, which for young children is $1\frac{1}{4}$ to $1\frac{1}{2}$ inches apart. The levers attached to the large screw by which pressure is applied are reversed, and the central pressure bar withdrawn, so that the foot can easily be placed between the bars. The os calcis and the concave surface of the tarsus is held between the opposing bars, when on the levers being turned the central pressure bar is pressed on the convex surface of the tarsus. The screw is forcibly turned until the tarsus is crushed and bent,

* 'Provincial Medical Journal,' July 2, 1894.

so that the foot presents the form of an aggravated flat foot. This process is repeated two or more times until all resistance ceases, or until the tarsus has been fractured. I wish to remark how unexpected and strange, it seems to me, is the amount of crushing, bending, and breaking a foot will bear with but little ill result, and very little after-pain to the patient. The pain mostly subsides after twelve hours, and the after-effect of the second operation is never as painful as that of the first. I have also to say that when operating with an osteoclast or wrenching with a Thomas's twister I invariably administer an anæsthetic.

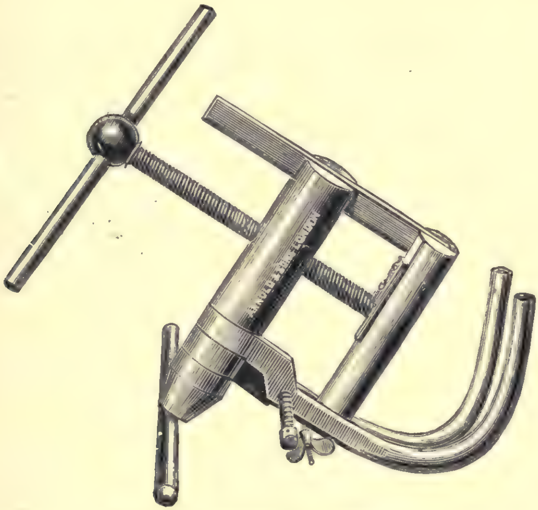


FIG. 129.—GRATTAN'S OSTEOCLAST.

The conclusions,' continues Dr. Grattan, 'I have come to with regard to this method of treatment are the following: That in forcible instrumental rectification with a tarsoclast we possess a powerful and ready means of correcting the deformities of club-feet which have resisted treatment by manual stretching and Thomas's wrench; that in order to succeed by this method it is necessary to sufficiently over-correct (or if possible, to fracture) the tarsus with the tarsoclast, the operation to be repeated at intervals until all resistance ceases and the foot has assumed its

normal shape; tenotomy of the tendo Achillis should also be performed should the equinus persist. It is also possible by these means, combined with osteoclasis of the tibia and fibula close to the ankle-joint and rotating the foot outwards, to make patients walk whom astragalectomy has failed to cure; nevertheless, until the individual has ceased to grow, in spite of every or any treatment, many of these resistant club-feet are liable to relapse.'

*Intermittent Forcible Rectification* (*Shaffer's Method*).—Shaffer recommends for severe intractable cases forcible traction applied from a few seconds to five minutes at a time every quarter or half hour. He combines this method in some instances with division of any fibrous and tendinous resisting bands. He has invented three forms of apparatus for applying the force: one for overcoming the equinus, two for overcoming the varus—one acting from the inner side of the foot as a pusher, the other acting from the outer side of the leg as a drawer. The apparatus is constructed on the principle of the Scarpa's shoe, and is accurately adapted to the shape of the deformed foot. The mechanism is very powerful. We have no experience of this method ourselves.

(2) **Tenotomy—General Remarks.**—Tenotomy consists in the division of a tendon for the purpose of permitting the restoration of the shape, functions, and normal anatomical relations of a deformed part. It may be performed subcutaneously, or by the open method.

**Subcutaneous tenotomy** consists in the division of a tendon through a minute puncture in the skin, which is immediately closed by a pad of antiseptic gauze, so as to exclude as much as possible the entrance of air into the wound. The division of tendons, but by the open method, was practised as early as the beginning of the seventeenth century by Minnius, Roonhuysen, etc., and later by Thilenius, Lorenz, and Sartorius, but it was not till two centuries later that a partially subcutaneous method was substituted for it by Delpech, who in 1816, divided the tendo Achillis through a wound an inch in length. It was left to Stromeyer, in 1831, to first practise the division through a mere puncture in the skin. It is undoubtedly owing to his teaching on the continent of Europe, and to that of Dr. Little and later Mr. Adams in this country, that the subcutaneous method at

present in vogue became popularized. Before the days of antiseptic surgery the subcutaneous possessed a great advantage over the open method, in that suppuration after it is practically unknown. Now, however, perhaps the only advantages that can be claimed for it are the smaller wound and consequent insignificant scar, the ease and facility with which it can be done, and, in short, the trivialness of the operation when compared to any operation, however small, involving an open wound. By some surgeons, however, the open method is now preferred, since they maintain that the division in this way can be made in a more thorough and complete manner and without the risk of injury of important neighbouring structures. In some situations, as in the division of the hamstring tendons for contraction about the knee, where it is not always easy by the subcutaneous method to avoid the division of the external popliteal nerve, and in the division of the tendon of the sterno-mastoid muscle where there is a risk of injuring some of the veins of the neck, there is no doubt something to be said in favour of the open method. But in other situations, where the division of the tendon by any surgeon possessing a fair anatomical knowledge can be safely and effectually performed by the subcutaneous method, an open wound, although we can confidently feel that such will heal by the first intention, seems to us a gratuitous injury.

We have no objection, on principle, to the open method, but our teaching has always been, that where a tendon can be as thoroughly and safely divided through a mere puncture of the skin, the subcutaneous method, as the more simple, should be employed. Even in the division of the tendon of the sterno-mastoid we prefer the subcutaneous method, since it leaves an almost invisible scar, and we hold that, when properly done, it is practically as safe as the division through an open wound.

Much stress has always been laid on the prevention of the entrance of air into the wound through the puncture in the skin, for fear of suppuration ensuing. As far as we know, some air generally does enter the wound, whatever precautions are taken to prevent it. We are quite sure, however, that it does no harm. Over and over again in the division of tendons, under our supervision, by our dressers, we have known air enter the

wound freely, as evidenced by air-bubbles escaping on making pressure over the site of the divided tendon; but although hundreds of tendons have been divided in the Orthopædic Department during the last ten years, we have never known suppuration but once to occur, and this was traced to the use of a septic knife. At the same time no more air should, of course, be permitted to enter than can be avoided. The presence of air in any quantity is, no doubt, an indication that the section of the tendon has not been very daintily done; and in every surgical operation our aim should certainly be to perform it in the neatest and best possible way. Again, much has been written upon the importance of dividing the tendon evenly, and with as little disturbance and injury to the surrounding parts as possible. With all this we agree; but we do not admit that the chief reason for insisting on these things is the fear of suppuration. We have seen tendons divided anything but neatly, and certainly with considerable disturbance of the surrounding tissues; but we repeat that we have never known suppuration or other trouble from this cause to occur. In our opinion, it is much more important to guard against the entrance of septic matter, than to take precautions to prevent the entrance of air into the wound, or to lay excessive stress on refinements in the actual cutting of the tendon. Our rules in the Orthopædic Department are strict as regards all antiseptic precautions.

*Preparation for the Operation.*—The part (the whole leg in the case of a child) should be first thoroughly washed with soap and water and a skin-brush, and when thus apparently cleansed, well sponged with carbolic lotion (1 in 20 to 40, according to the age of the patient), and then finally covered with sal-alembroth gauze wrung out of corrosive sublimate solution (1 in 500) till all is ready for the operation. The tenotomes in the meantime should be placed in carbolic lotion (1 in 20). The operator's, the assistants', and the nurses' hands should be washed in hot water with soap, and rinsed in carbolic lotion or corrosive sublimate solution, the nails being cleansed with a nail-brush. All being ready, the limb should be laid upon a towel wrung out in carbolic acid (1 in 20), and the seat of operation packed round with a similar towel to protect it from any contact with the clothes. The same precautions, it will be seen, are taken to ensure an aseptic wound

in this little operation as are invariably taken by us in the performance of any other surgical procedure involving a breach of the integuments, however small or of whatever magnitude, and we are strongly impressed with the importance of so doing, for, although without any such care tendons are no doubt often divided with impunity, still, we have known, in the practice of the hospital before the days of antiseptic surgery, simple division of the palmar fascia followed by septicæmia and death. No care, we maintain, is too great to take to prevent such an accident, which may be truly called a surgical calamity.

*Instruments required.*—Tenotomy knives, or tenotomes as they are called, sharp-pointed and blunt, of various sizes, are necessary. The forms we employ are figured in the accompanying

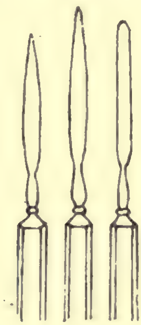


FIG. 130.—TENOTOMES FOR SUBCUTANEOUS TENOTOMY.

illustration. The blade of the tenotome should be sufficiently strong throughout its length to ensure it not breaking across in the division of a tough tendon. A larger and stronger one is, of course, required for the more resisting tendo Achillis of an adult than for the delicate tibial tendons of an infant. The point of the sharp-pointed tenotome should be centrally placed as regards the blade, *i.e.*, equidistant from the cutting edge and the back, and the back of both the sharp and blunt pointed knives should be smooth and rounded. The cutting edge should only extend for about an inch from the point, and should be slightly convex in contour. The tenotomes should always be kept well sharpened. Different forms are preferred by different surgeons; but we do not consider the form ourselves of much importance. For the division

of ligaments, Mr. Parker recommends a tenotome with a slightly-curved blade (Fig. 131). We have found, however, the ordinary straight tenotome answer equally well. The sharp-pointed tenotome is used for puncturing the skin, and for dividing the tendon in most situations; but where an artery or nerve is in the near neighbourhood of the tendon, it is safer to substitute the blunt-pointed knife for the sharp one after having punctured the skin and the tendon-sheath. If the blunt end comes into contact with the artery or nerve, it would tend to push it aside, whereas the sharp-pointed knife might prick it. If an artery is injured with the blunt-pointed knife, it will be probably the result of the knife having been passed beneath it; the artery therefore would most likely be completely severed—an injury much less liable to give rise to subsequent trouble than a mere prick or partial division of a vessel.

*Question of Anæsthetics during Tenotomy.*—Except in certain situations, as in the division of the sterno-mastoid or of the ham-string tendons, where several punctures may be necessary, an anæsthetic is not required, unless forcible stretching or wrenching of the parts is subsequently to be made. In the mere division of the tendo Achillis or plantar fascia, the pain is so trivial that even local anæsthesia by means of cocaine is not called for; indeed, the puncture with the needle of the syringe gives almost as much pain as the prick of the tenotomy knife. For nervous patients and unruly children there is no objection to a general anæsthetic if it is desired. When chloroform is given, however, the administrator will do well to bear in mind that there is sometimes a sudden lowering of the blood-pressure at the moment a tendon is severed; the patient therefore should not be placed too deeply under its influence. Freezing with ether, as recommended by some, is objectionable, in that the parts are rendered so hard whilst frozen that it is exceedingly difficult to be sure that the tendon is divided. If cocaine be employed, only a weak solution, *i.e.* one of 1 or 2 per cent., should be injected, as recommended by Réclus,* as with this strength and with the patient recumbent no dangerous symptoms have been found by him to ensue. A hypodermic syringeful of a 1 per cent. solution represents $\frac{1}{6}$ of a grain of cocaine. The quantity injected should never exceed $2\frac{1}{2}$ to 3

* Réclus, Dr. P., 'Cocaine in Surgery,' *Medical Week*, Jan. 27, 1893, p. 37.

grains, 3$\frac{2}{3}$ grains having caused death. Much less quantities will suffice for such operations as division of tendons. For our own part, we seldom employ local anæsthesia.

*Operation—Method of making the Puncture.*—The part should be firmly held by an assistant, and the tendon, when superficial, stretched and made prominent in the way hereafter described. The surgeon having defined the situation and borders of the tendon when superficial, or determined the spot for the puncture by a consideration of the landmarks when the tendon is deep, punctures the skin with a sharp-pointed tenotome. The exact situation at which the puncture should be made and the tendon divided will be considered later under the head of 'Tenotomy of Various Tendons.' The puncture should be a mere prick, as small as possible, merely sufficient to allow the blunt-pointed tenotome to pass; and in the subsequent manipulation care should be taken not to enlarge it by allowing the cutting edge of the tenotome to come into contact with the skin. The puncture is usually made with its long axis in the same direction as that of the tendon, the tenotome being passed with the flat of the blade parallel to the tendon. If the tendon is deep and enclosed in a fibrous sheath, this should be opened by the sharp-pointed tenotome.

*Method of dividing the Tendon.*—The tendon may be divided (1) by passing the tenotome between the tendon and the skin, and cutting towards the deeper structures; or (2) by passing the Tenotome beneath the tendon and cutting towards the skin.

(1) In the former method the tenotome is passed with the blade still on the flat between the tendon and the skin; its edge is then turned towards the tendon, the assistant in the meanwhile making the tendon tense and resisting by manipulating the foot. The delicate tendon of the infant, when made tense over the edge of the knife, cuts itself through, as it were, without any movement of the knife on the surgeon's part, but the tough tendo Achillis of the adult requires some movement of the knife for its division.

The tendon is known to be divided by the cessation of resistance to the knife, and generally by a distinct snap. The tenotome is then again turned with the blade on the flat, and thus withdrawn so as not to render the wound T-shaped. The puncture is immediately covered with a pad of antiseptic gauze, secured by

strapping. By some surgeons a pad of cotton-wool soaked in iodoformized collodion is substituted for the antiseptic gauze.

(2) In the second method the tenotome is passed *beneath* the tendon, with the blade on the flat; and when the point has reached just beyond the tendon, the cutting edge is turned towards it, and the section made outwards towards the skin. Whilst the tenotome is being passed beneath the tendon, it is recommended by some surgeons that the tendon be relaxed. This, it is said, facilitates the passage of the knife beneath it. We prefer the tendon being made tense during this procedure: its deep surface is, in our opinion, thus better defined, and there is less risk of the tenotome transfixing it. At the moment of severance it is also advised that the assistant should again relax the tendon to prevent the knife perforating the skin over it, and thus converting the subcutaneous into the open operation. Such an accident, however, is better guarded against by the surgeon having his hand well under control.

Of the two methods, we prefer as a rule the latter. It is, perhaps, a little more difficult, and there may be some trouble, especially if the tendon is relaxed, in passing the knife beneath it; the inexperienced operator, moreover, may run some risk, if he is not careful, of forcing his knife through the skin at the moment the tendon gives way. We teach, however, both methods, and do not think there is much more to be said in favour of one than of the other.

**Tenotomy through an Open Wound**, the *ténotomie à ciel ouvert* of the French, has, since the days of antiseptics, been adopted by some surgeons to the exclusion of the subcutaneous method. We mentioned, in briefly referring to the history of tenotomy, that the open method was practised long ago by the older surgeons, but was abandoned for the subcutaneous on account of the suppuration and other troubles which so frequently attended in former times any open wound. At the present day, the open method, thanks to the more scientific treatment of wounds, has lost its terrors, and is recommended and employed by some surgeons for all cases requiring tenotomy. We have already remarked that, in the division of the tendon of the sterno-mastoid and the hamstring tendons, there is something to be said in its favour; but to employ it, for instance, in the division of the

tendo Achillis, an operation which can be done by the subcutaneous method with such facility and safety, is, to our mind, a retrograde step. To speak of the passage of a tenotome beneath this tendon through a puncture in the skin as groping in anatomical darkness is a little strained, since no operation in surgery, we should imagine, could be done with more accuracy and precision. The only tenotomies we have ourselves performed by the open method have been the division of the sterno-mastoid and hamstring tendons. But, save under exceptional circumstances, even here the subcutaneous method has been by us invariably employed. We are bound to say, however, that distinguished authorities, especially in France, recommend the open method.

*Method of Operating.*—The patient having been placed under local or general anæsthesia, either a transverse or vertical incision is made over the situation of the tendon, which is rendered tense by an assistant. The tendon being fully exposed, it is divided either with or without a director passed beneath it. By some the division is made with blunt-pointed scissors. Any bleeding vessels having been tied, the wound is accurately united by suture, and dressed in the ordinary way.

*Accidents after Tenotomy.*—We may say at the outset that the only troubles we have ourselves had have been suppuration in one case after division of the tendo Achillis, and a traumatic aneurysm in another after division of the plantar fascia. We have seen the posterior tibial artery, the anterior tibial artery (sometimes both at the same time), and the internal plantar artery, wounded, but save in the one case above mentioned no harm whatever has ensued. A firm bandage has been applied over the wound, which has been closed in the ordinary way, and the foot placed in plaster of Paris.

The accidents which may occur, however, are: (1) suppuration; (2) erysipelas; (3) purulent teno-synovitis; (4) hæmorrhage; (5) aneurysm; (6) septicæmia or pyæmia; (7) non-union or weak union of the tendon. All these accidents, however, must be very rare when antiseptic precautions and due care are taken, seeing that, with the exception of the two mishaps mentioned above — namely, suppuration in one case, and a traumatic aneurysm in another—though many hundreds of tendons have been divided in the orthopædic department, all the cases, notwithstanding they were out-patients, have done well.

*After-treatment of Tenotomy Cases.*—After tenotomy it was formerly the almost universal custom amongst orthopædic surgeons to place the foot in retentive apparatus in the position in which it was before the operation, so that the ends of the divided tendon might be in contact. The foot was then kept in this position for four or five days until the puncture in the skin was healed. The rectification of the foot was subsequently carried out by gradual extension by means of some cogwheel apparatus, as a Scarpa's shoe or its various modifications, or by means of bandaging the foot to a splint.

It was taught by most orthopædic authorities, and is still held by some, that if the ends of the divided tendon were not thus kept in contact, or nearly in contact, till the puncture had healed, or if the extension was commenced too soon, inflammation and suppuration might follow, or the tendon fail to unite, or feeble union with too great an elongation of the tendon ensue, and it was said that under such circumstances an equinus might become a calcaneus.

Professor Syme, however, was accustomed to allow his patients after division of the tendo Achillis to walk at the end of the third day, so that the weight of the body might rectify the foot. His teaching was strongly combated by London orthopædic surgeons, and it was not till recent years that the method of rectifying the foot immediately after division of the tendon came into vogue.

At the present day, whilst some continue to practise gradual extension, others, though they do not immediately rectify the foot, still carry out extension more rapidly than formerly. The methods of treatment after tenotomy, therefore, may be divided into (1) Immediate rectification; (2) rapid extension; (3) slow extension.

(1) *Immediate Rectification.*—For the last five or six years we have, after division of the tendo Achillis, immediately placed the foot in the best position towards correction into which it could be forced, and retained it in this position at rest for a week. In no single instance has non-union occurred; nor have we met with a weak tendon. Indeed, if anything, a stouter and stronger tendon has resulted than when we practised the older method of gradual extension. In some instances the divided ends have been left as much as an inch or an inch and a half apart—invariably, we should

say, a quarter to half an inch. It has been our practice to force the foot into the position of dorsiflexion, as far as it would go, without giving any thought to the distance the divided ends of the tendon might be apart; but still good and sound union has ensued. In dealing with other tendons we have also employed the same method, and although, in the case of the posterior tibial tendon, it is difficult in consequence of its deep situation to affirm that it always unites after the method of immediate extension, we have no reason to believe that it has not done so. With regard to the anterior tibial tendon and the extensor tendons on the dorsum of the foot and toes, we have always found them readily unite, though the distance between the divided ends has sometimes been extreme.

In speaking of immediate rectification after tenotomy, we would say that complete rectification cannot *always* be accomplished (in some cases, as after division of the tendo Achillis for severe congenital varus, we would say *seldom*), the ligamentous contractions and alterations in shape of the bones and their articular facets not allowing the foot to be brought at once into the normal position. What we mean, then, by immediate rectification after tenotomy, is rectification of the foot as far as it is possible; that is, within the limits in which it is held by the contracted tendon. In paralytic cases, where there is no ligamentous rigidity, complete rectification can frequently, after division of the tendon, be immediately obtained.

The methods of fixing the foot in the rectified position are various. Thus, it may be fixed on a splint, in some form of talipes-shoe, in a leather or poroplastic case, or in plaster of Paris. The method we invariably employ is the plaster method. This is given in detail at p. 146.

(2) *Rapid Extension.*—In this method the ends of the divided tendon are only slightly separated immediately after the operation, the foot being fixed in plaster of Paris or some apparatus for three or four days, and then further corrected weekly or bi-weekly till the desired result is obtained.

(3) *Slow Extension.*—In the method of slow or gradual extension the foot is placed immediately after the operation in the position in which it was before the tendon was divided. It is thus held in a Scarpa's shoe or other apparatus for four or five

days to a week, till the puncture is healed. The screw of the apparatus is then gradually turned till the rectification is complete. (See 'Mechanical Extension.') It was formerly taught that in this way the tendon was allowed to unite, and that the uniting material, whilst young and yielding, was gradually stretched by the apparatus. According to Mr. Adams, however, it is not so much that the uniting material is stretched, as that the material laid down between the divided ends is regulated in amount by gradually separating the ends of the tendon.

**Tenotomy of Special Tendons**—*Division of the Tendo Achillis.*—We invariably divide this tendon by the subcutaneous method, since there is no structure of importance in the immediate neighbourhood that can be injured if ordinary care is taken. In the fat leg of the infant the posterior tibial artery which lies behind the inner ankle might be wounded if the tenotome is entered too near the internal malleolus, or if its point, when the tendo Achillis is divided from the outer side, is directed forwards and inwards towards the internal malleolus. To avoid this accident, Mr. Adams recommends that the tendo Achillis in the infant be divided from the outer side. It has seemed to us, however, that the artery is more likely to be pricked by the inexperienced when the tenotome is thus passed, than when entered from the inner side.

*Method of dividing the Tendon.*—The skin having been cleansed in the way already mentioned (p. 186), the patient should be placed on his right or left side, according as the right or left foot is to be operated upon, or, if preferred, upon his stomach. Except for very resistive or nervous patients and for unruly children, an anæsthetic is unnecessary, since the operation can be done very expeditiously and is attended with but little pain. For the last few years nearly all our tenotomies of this tendon at the hospital have been done without an anæsthetic. When all is ready for the operation an assistant takes hold of the foot and leg, and attempts to dorsal-flex the foot, so as to put the tendon on the stretch and make it stand out prominently. The surgeon, having defined the inner edge of the tendon, enters a sharp-pointed tenotomy knife, with the flat of its blade held parallel to the longitudinal axis of the tendon, at a spot corresponding to the narrowest part of the tendon, *i.e.*, just above its insertion into

the os calcis where it can be readily felt under the skin. Keeping the point close to the tendon, he carries the blade of the tenotome beneath it. The cutting edge of the tenotome is now turned towards the tendon, the handle depressed, and the tendon divided. By some surgeons it is recommended that the tendon should be relaxed by the assistant plantar-flexing the foot whilst the knife is being passed beneath it. We prefer it being kept tense during this procedure, as, when this is done, we think there is less risk of the knife penetrating the tendon instead of passing beneath it. It is also recommended that the assistant should relax his efforts at dorsal-flexion at the moment the tendon is felt to give way with a snap, lest the surgeon's knife divide the overlying skin. There is, it has always seemed to us, very little danger of this happening if the surgeon keep his left forefinger over the spot where the division is being made, and have his cutting hand well under control. On the division of the tendon the finger is placed over the puncture, and a small pad of antiseptic gauze is applied and secured by two strips of strapping fixed on crosswise.

There is a point, however, in the application of the strapping that the surgeon will do well to look to; namely, not to apply it transversely across the position of the divided tendon. When this is done, the strapping, if put on at all tight, presses in the skin between the divided ends of the tendon towards the bone, and, in consequence, reduces the space wherein the new material for the repair of the divided tendon is laid down. The result of such a faulty application of the strapping may be a weak tendon, or even non-union of the tendon. Indeed, such cases have been reported.

*Chief Deformities that may call for Division of the Tendo Achillis.*—(1) Talipes equinus (congenital and acquired); (2) congenital talipes varus; (3) paralytic talipes equino-varus; (4) rectangular talipes, or right-angled contraction of the tendo Achillis.

*Division of the Tendon of the Tibialis Anticus.*—This tendon may be divided either in front of the ankle-joint, or just above its insertion into the internal cuneiform bone on the inner side of the dorsum of the foot. The former position is generally chosen in congenital club-foot, as here the tendon stands out most prominently. The tendon at this situation lies in the innermost of

the sheaths in front of the ankle, and has the anterior tibial artery to its fibular side, but separated from it by the extensor proprius hallucis. At its insertion it lies on the tarsal bones at some little distance from the artery, with the tendon of the extensor hallucis still between them.

*Alteration in the Relations of the Tendon in Congenital Varus.*—The tendon in severe cases of congenital varus is drawn somewhat more inwards than natural, lying on the inner surface of the internal malleolus rather than in front of it. In fact, in very severe cases it lies almost in the situation below the internal malleolus normally occupied by the posterior tibial tendon.

(A) *Method of dividing the Tendon in Front of the Ankle.*—The patient should be placed on his back, with the leg rotated outwards; the assistant, standing opposite the operator, grasps the foot with one hand, and the leg a little above the ankle with the other, and makes the tendon tense and prominent by plantar-flexing and abducting the foot, but may relax a little, if the surgeon desires it, whilst the tenotome is being passed beneath the tendon. The surgeon should stand on the opposite side of the limb to that of the tendon, facing the patient when the left foot is to be operated on, but with his back to the patient when the tendon of the right foot is to be divided. Having defined the situation of the tendon, the surgeon places his thumb over the spot at which he intends to make the division, and, keeping it there, enters the tenotome, held on the flat, to the outer side of the tendon between the latter and the extensor proprius hallucis, so as to avoid injuring the anterior tibial artery. When the tenotome is well beneath the tendon, the cutting edge is turned towards it, and the division made from below upwards towards the skin. The assistant may relax the part somewhat at the moment of the division, so that the tendon may not give way too suddenly, and the tenotome be forced through the overlying skin.

Some surgeons prefer dividing the tendon from above downwards towards the bones. The skin is pinched up from the tendon to facilitate the passage of the knife, and the latter, which is passed with the blade on the flat between the tendon and the skin, is then turned with its cutting edge towards the tendon, and the division made by cutting towards the bones.

(B) *Method of dividing the Tendon at its Insertion.*—The operator and his assistant taking up similar positions as regards the patient, and the tendon having been made tense as for division in the former situation, the skin is pinched up over the tendon, and the tenotome passed with the blade on the flat between the skin and the tendon. The edge is then turned towards the tendon, and the division made by cutting towards the bones.

*Chief Deformities that may call for Division of the Tibialis Anticus Tendon.*—(1) Talipes varus (congenital and paralytic); (2) paralytic talipes equino-varus; (3) congenital talipes calcaneus.

*Division of the Tendons of the Extensor Longus Hallucis, Extensor Longus Digitorum and Extensor Brevis Digitorum.*—These tendons may be divided subcutaneously as they cross the dorsum of the foot—the extensor longus hallucis anywhere between the anterior annular ligament and its insertion into the last phalanx of the great toe; the extensor longus digitorum as a whole immediately below the anterior annular ligament; or each separate tendon on the dorsum of the four outer toes. The tendons of the extensor brevis digitorum may also be divided on the dorsum of the toes. To divide any of these tendons, the foot, or any separate toe which may be alone affected, is first plantar-flexed to put the tendon on the stretch. The tenotome is then passed beneath the prominent tendon, which can be readily felt beneath the skin, and the tendon divided either by cutting from below upwards through the tendon towards the skin, or from above downwards from between the skin and the tendon through the tendon towards the bone. In dividing the tendon of the extensor longus hallucis, the tenotome should be passed from the *fibular* side so as to avoid the anterior tibial and its continuation, the dorsalis pedis artery. In dividing the common extensor tendon of the toes, the knife for the same reason should be entered on the *tibial* side. In the division of the innermost tendon of the extensor brevis digitorum, it should be remembered that the dorsalis pedis artery runs beneath the tendon just before the vessel passes through the first interosseous space to enter the sole of the foot.

*Chief Deformities that may call for Division of the Extensor Longus Hallucis and Extensor Longus Digitorum Tendons.*—The

extensor longus hallucis may have to be divided for the clawed condition of the great toe sometimes met with in talipes equinus, in rectangular talipes, and in talipes cavus. The extensor longus digitorum may require division in the clawed condition of the toes in talipes cavus and talipes equinus.

*Division of the Tendons of the Tibialis Posticus, Flexor Longus Digitorum, and Flexor Longus Hallucis.*—The tibialis posticus may be divided subcutaneously just above the internal annular ligament, where it lies behind the internal malleolus, or immediately below the internal annular ligament, just above its insertion into the tubercle of the scaphoid bone. Where it lies beneath the internal annular ligament it is contained in a dense fibrous sheath, and its division would be attended with considerable difficulty.

The tendon whilst behind the internal malleolus lies in a groove on the tibia common to it and the flexor longus digitorum. The latter tendon separates it from the posterior tibial artery and nerve, which lie still further behind and nearer to the os calcis. As the tendon passes round the inner ankle, it is contained in a distinct sheath formed for it by the internal annular ligament. Just before its insertion into the tubercle of the scaphoid it lies upon the internal calcaneo-scaphoid ligament. In the normal state of the parts the tendon runs vertically downwards behind the internal malleolus, and then turns forwards beneath the internal malleolus, and, passing obliquely forwards and downwards over the internal lateral ligament of the ankle-joint and calcaneo-scaphoid ligament, reaches its insertion into the scaphoid. In the normal adult foot it can in this position be distinctly felt when the muscle is put into action.

In severe cases of club-foot, however, the scaphoid bone is drawn directly beneath the internal malleolus, with which it sometimes forms an articulation. The tendon, instead of passing obliquely downwards and forwards beneath the internal malleolus, passes directly downwards, at times, it is said, with 'a slight inclination backwards away from the malleolus to an expanded insertion into the tubercle of the scaphoid.'*

By some surgeons it has been maintained that the tendon cannot be divided in severe cases of club-foot below the internal

* Little, 'Club-foot.'

malleolus, in consequence of the above-mentioned alteration in the anatomy of the parts. It is divided here, however, both in the operation of subcutaneous division of the astragalo-scaphoid capsule (p. 208), and in that of Phelps' open incision of the soft tissues on the inner side of the foot down to the bones.

Syme recommended its division below the malleolus, and this situation is preferred by Mr. Parker, amongst others, to that above the malleolus. Here, in severe cases of varus, it may be sometimes a little difficult to divide the tendon; but we have never met with a specimen in which it could not be done. It is true that in this situation the tendon often spreads out into a fibrous expansion before its insertion into the tubercle of the scaphoid, and it may be a question whether this unites in the same way, if at all, as an ordinary rounded or flattened tendon.

(A) *Division of the Tendon above the Internal Lateral Ligament behind the Internal Malleolus.*—In this situation the inner border of the tibia, on which in the adult there is often a small tubercle about an inch and a half above the tip of the malleolus, serves as a guide to the tendon. A spot immediately behind this tubercle (posterior tibial tubercle) is usually selected for making the puncture in the division of the tendon in the adult. In the fat and chubby leg of the infant the inner border of the tibia cannot, as a rule, be distinctly felt. The best guide to the tendon is, then, that given by Dr. Little,* namely, 'a spot exactly midway between the anterior and posterior borders of the leg on its inner aspect,' and about half an inch above the apex of the internal malleolus.

*Method of Operating.*—The limb being placed on its outer side, the surgeon should stand on the opposite side of the leg to that of the tendon, with his back turned towards the patient when operating on the right, but facing him when operating on the left foot. The assistant, facing the operator, should grasp the foot with one hand and the leg just above the ankle with the other, and firmly dorsal-flex and abduct the foot in order to make the tendon tense. The skin having been cleansed in the way already described, the surgeon makes a puncture with a sharp-pointed tenotome at the spot above indicated, holding the knife perpendicular to the inner surface of the leg, and with the flat of its blade

* Thompson, 'Trans. Path. Society,' vol. vi., p. 358.

parallel to the inner border of the tibia. The sharp-pointed tenotome should be passed into the sheath of the tendon to make a way for the blunt-pointed. It should be then withdrawn, and the blunt-pointed substituted for it. The blunt-pointed knife having been carefully insinuated into the puncture in the sheath, and between the posterior surface of the tibia and the tendon, its edge should be turned towards the tendon, and the latter divided by cutting outwards towards the skin. Whilst the knife is being passed beneath the tendon, the assistant should relax the parts by plantar-flexing and adducting the foot, but he should again make the tendon tense when the knife is *in situ*, and its edge has been turned towards the tendon by abducting and dorsal-flexing the foot.

It is not always easy in the infant—indeed, it is sometimes very difficult—to be sure that the tendon has been divided, as there may not be the sudden and audible snap as after division of the tendo Achillis. The surgeon before cutting, therefore, should try and convince himself that the tenotome has passed between the tendon and the bone. The better to ensure this, the sheath should be well opened by the sharp-pointed tenotome, close to the bone, and the surgeon should not feel satisfied that the blunt-pointed tenotome is beneath the tendon unless it is felt locked between the tendon and the bone when he tries to move it from side to side. If the tendon is not hit off, it may be sought by the blunt tenotome used as a probe. If not found, the sharp-pointed knife should be re-introduced, and the opening in the sheath enlarged; or it may be that on the first puncture the surgeon has failed to penetrate the sheath at all. In the adult and in the child the inner border of the tibia is a certain guide to the sheath; but in the infant the tibia has no distinct inner border, the bone being rounded rather than angular, and in severe cases of the deformity the tendon, as pointed out by Mr. Adams, may be displaced somewhat forwards, so that it lies on the malleolus rather than behind it.

Although the surgeon himself may not feel the tendon yield, the assistant will generally do so, and, if he is accustomed to hold the foot for this operation, will be able to satisfy the surgeon that the division has taken place. If it is desired to divide the flexor longus digitorum as well as the tibialis posticus, the blunt-pointed

tenotome, after it has been passed between the tibial tendon and the bone, should be pushed onwards a little further, and then turned with its edge towards the tendons, and both divided at the same time by cutting outwards towards the skin.

The object in substituting the blunt-pointed for the sharp-pointed tenotome after the sheath has been opened is to avoid pricking the posterior tibial artery with the point of the tenotome —a danger specially liable to happen if the flexor longus digitorum as well as the tibialis posticus is divided, since the artery lies immediately behind the latter. With the blunt-pointed knife the artery may be pushed aside, or, if injured at all, completely divided, and trouble is much less likely to ensue after a complete division than after a mere puncture of the artery. Should the artery be injured—an accident which may be known by a spurt of blood, and, perhaps, by some sudden blanching of the foot—the wound should be closed as usual by a pad of antiseptic gauze, firm pressure applied over the pad and the course of the artery, and the foot and leg placed in plaster as usual. We have several times seen this artery injured, but no trouble of any kind has ensued. A traumatic aneurysm has, however, been known to follow a puncture of the vessel. On no account should the artery be sought in the wound and ligatured ; pressure is quite sufficient.

(B) *Division of the Tendon below the Internal Lateral Ligament in front of the Apex of the Internal Malleolus.*—The foot being held by the assistant as before, with the leg rolled outwards, the surgeon, standing in the same position, makes out the astragalo-scaphoid joint, pinches up the skin, and introduces the sharp-pointed tenotome between the skin and the tendon. The knife is then turned towards the tendon, and the latter divided by cutting towards the bone. In severe cases of congenital varus, where the scaphoid is in contact with the external malleolus, the sharp-pointed tenotome should be introduced immediately in front of and below that process, and the knife passed between the malleolus and the scaphoid. Through this puncture the astragalo-scaphoid capsule may be divided if desired at the same time (see p. 208). The tendon of the flexor longus digitorum and flexor longus hallucis also may be divided through this puncture by passing the tenotome deeper into the foot and keeping it close to the bone. In this situation, Mr. Parker says, the two

tendons can be simultaneously divided just where they cross each other.

*Chief Deformities that may call for the Division of the Tendons of the Tibialis Posticus and Flexor Longus Digitorum.*—(1) Congenital talipes varus. The indications for the division of these tendons in congenital talipes varus are: (*a*) extreme inversion of the foot, and (*b*) inversion of the foot that can only be partially overcome when an attempt is made to abduct the foot. (2) Paralytic talipes varus; (3) talipes equino-varus.

*Division of the Plantar Fascia and Short Muscles of the Sole of the Foot.*—Subcutaneous division of the plantar fascia may be done either about the middle of the foot where the contracted band is usually most distinct, or more posteriorly just in front of the attachment of the fascia to the os calcis. The former situation is the one generally recommended. Here the fascial band is commonly most prominent, and can be readily defined, and is therefore more easily divided. We prefer, however, the latter situation, inasmuch as the fascia near its insertion is covered by a thick pad of skin and subcutaneous tissue, and its division is not followed by the cicatricial contraction and adhesion with dimpling of the skin that is apt to occur after division of the fascia further forward where the subcutaneous tissue and skin covering it are thin and the fascia is consequently nearer the surface. The cicatrix then left, moreover, is generally painful for a few weeks, and remains tender on pressure for months. Further, the posterior incision ensures the complete division of the fascia before it breaks up into its various bands.

The division may be made with a sharp-pointed tenotome only, or, after the skin has been punctured, the blunt-pointed tenotome may be substituted for it. We do the whole of the division ourselves with a sharp-pointed knife. If the surgeon, however, is unaccustomed to the operation, he had better, after having perforated the skin, use the blunt-pointed knife for the rest of the operation, since with the sharp-pointed knife there is a risk of pricking the internal plantar artery. We have known such an accident to be followed by a circumscribed traumatic aneurysm of the internal plantar artery. With the blunt-pointed knife, the artery, if injured, will probably be cut completely across, and no particular harm will be then likely to ensue. Firm pressure over

the divided vessel and the posterior tibial, where it lies behind and below the internal malleolus, is quite sufficient to prevent any hæmorrhage.

*Operation.*—The foot over the area of the puncture, having been properly prepared as for any other surgical operation, is laid on its outer side, and the fascial band made tense by an assistant taking hold of the leg just above the ankle with one hand, and the fore part of the foot with the other, and attempting to dorsal-flex the foot. When the fascia is to be divided at the middle of the foot, *i.e.*, about its narrowest part, the surgeon, having made out the exact position of the band with his finger, passes the tenotome, held with the flat of the blade parallel to the fascia, through the skin, and if the whole of the division is to be made with a sharp-pointed knife, directs the tenotome beneath the fascia and then turns the edge towards the fascia and divides it, cutting upwards towards the skin. If neatly done the fascia gives way on its division with a distinct snap. The assistant is advised to relax his pressure on the foot the moment the fascia yields, so that the knife may not be forced through the skin. To prevent this happening, some surgeons pass the tenotome between the skin and the fascia, and then cut through the fascia towards the sole of the foot. A freer division may by the inexperienced be ensured in this way, but it takes a little longer to insert the knife between the skin and fascia, and consequently gives more pain. When the division is made from within outwards, the tenotome is apt merely to transfix the fascia, leaving the deeper portion undivided, in consequence of the surgeon hesitating to pass the tenotome sufficiently deep into the foot. After division of the more prominent bands of fascia, other fascial bands or tense and contracted sole-muscles often become prominent. These should be freely divided through the same puncture when they can be got at, or through a separate puncture if necessary. Our rule has been, after the chief or most prominent band of fascia has been divided in the usual manner from below upwards towards the skin, to rapidly turn the edge of the tenotome towards the sole, and cut freely in the direction of the bones till no prominent band of any kind can be felt. To make certain in equino-varus that all contractions in the sole have been dealt with, the assistant is directed to abduct as well as dorsal-flex the foot. When this is done, a tense band

to the inner side of the tenotomy puncture often becomes evident, and should be divided by passing a knife beneath it.

When the division is made near the attachment of the fascia to the os calcis, the knife is passed deeply into the side of the heel, below and posterior to the line of the posterior tibial artery or its division into the plantar arteries, and the fascia divided by cutting towards the skin or towards the bone. It is difficult to describe how deep or how superficial the tenotome should be inserted to get beneath the fascia. If on cutting towards the skin the fascia is not felt to yield with the usual snap, the knife is probably superficial to it. The surgeon should then turn the knife towards the bone and cut in that direction. After the division of the fascia in this situation, other bands on the inner side of the sole may require division further forward. On withdrawing the tenotome the surgeon should immediately close the puncture with his forefinger, and at once put on the pad of antiseptic gauze, and secure it by strips of strapping.

On the conclusion of the little operation, the surgeon should well wrench the foot in the direction of straightening out the contracted sole, and thus ensure the giving way or stretching of any contracted bands that may have escaped, or may have been only partially divided by the knife, and place the foot, corrected as much as possible, in a plaster of Paris bandage. We always employ cotton-wool beneath the plaster. In the adult a domett bandage may be substituted for the cotton-wool, but in the infant the cotton-wool should invariably be employed. The plaster bandage should be kept on for a fortnight or three weeks, and then either removed and reapplied, or some other form of extension apparatus used in its stead. If extension is not kept up for several weeks, recontraction is liable to occur.

*Chief Deformities that may call for Division of the Plantar Fascia.*—(1) Congenital talipes varus, where there is much contraction of the sole and inner side of the foot. The division is usually recommended to be made after the division of the tibial tendons, if this is necessary, and before the division of the tendo Achillis. Some surgeons, however, recommend that the tibials, the fascia, and the tendo Achillis should be divided at the same time. We have usually followed the teaching of Mr. Adams, and divided the structures on three separate occasions. (2) Talipes

equinus associated with cavus. In this affection we have always divided the fascia before the tendo Achillis. By leaving the tendo Achillis for a subsequent operation, the heel is held firmly, and the stretching of the sole can be better accomplished. It was Mr. Adams who was the first to recommend this procedure, making use of the contracted state of the tendo Achillis as a means of fixing the posterior extremity of the arch of the foot, so as to afford sufficient resistance to the force employed anteriorly. (3) Rectangular talipes with cavus. In this condition, and for the same reasons, we have usually divided the plantar fascia first, reserving the division of the tendo Achillis till the unnatural arching of the foot has been overcome. (4) Talipes cavus without contraction of the tendo Achillis. (5) Paralytic talipes varus and equino-varus.

(3.) **Syndesmotomy—General Remarks.**—Syndesmotomy, or the division of ligaments, may be performed by the subcutaneous or by the open method.

**Subcutaneous Syndesmotomy** is the free division of the ligaments through a minute puncture in the skin.

The part that the ligaments play in keeping up the deformity after division of the contracted tendons has been recognised by many writers on club-foot, and in 1868 Professor Iklekeisen,* of Bâle, recorded successful cases of the division of ligaments, and strongly recommended the operation; but it was left to Mr. R. W. Parker to bring this method prominently before the profession, and to advocate it as a routine treatment in suitable cases.†

The *operation* is performed in a way similar to that of tenotomy. The skin having been thoroughly cleansed and rendered aseptic in the manner stated under tenotomy, the surgeon defines the point for making the puncture, introduces the tenotome, and divides the contracted ligaments by cutting towards the bones. The assistant, whilst the ligaments are being divided, makes them tense by so moving the foot as to put them on the stretch. After all the contracted bands that can be felt have been severed, the tenotome is withdrawn and the puncture closed

* 'Notizen ueber Bau und Behandlung der Klumpfusses.' Jahrbuch für Kinderheilkunde, Band ii., 1869, p. 49.

† Parker, 'Congenital Club-foot,' 1887.

by a dossil of antiseptic gauze, which is secured by strapping. The foot is now forcibly wrenched in a direction as much as possible towards the normal position, in order to break down any ligamentous bands that may have escaped the knife, and is then secured, as after tenotomy, in some form of retentive apparatus. For this purpose Mr. Parker recommends plaster of Paris, and this is the material we have always used ourselves. The plaster bandage, applied in the way stated at p. 146, is kept on for a week. On its removal, we have invariably found the puncture healed and the parts in a quiet state. No inflammatory or other trouble in our experience of the operation has occurred —indeed, our syndesmotomies have done equally well in all respects as our tenotomies. We would lay great stress, however, on the special importance of aseptic or antiseptic precautions; for it should be remembered that in the division of the ligaments certain of the joints of the tarsus are laid open, and, should inflammation follow, very grave injury to the foot might ensue.

The division of the ligaments no doubt greatly facilitates the immediate rectification of the foot, and in suitable cases, we believe, expedites the cure. Thus, the division of the astragalo-scaphoid capsule, as it is called by Mr. Parker, allows of the scaphoid being wheeled round on the head of the astragalus, and so permits of the varus position being rapidly overcome. The operation, however, appears to us to be open to the theoretical objection that the rectification of the deformity is only accomplished at the expense of the separation, more or less complete, of the articular surfaces of the bones, the deformity of the bones themselves, if such exists, remaining untouched. In slight cases, where the neck of the astragalus is little if at all deflected, and the varus is the result more of the displacement of the scaphoid with the bones in front of it on the head of the astragalus, the division of the ligaments holding the scaphoid in its displaced position is undoubtedly of service. Of late we have on several occasions resorted to it where, after division of the posterior tibial tendon, the scaphoid, as shown by the internal malleolus not becoming prominent, could not be drawn away from the internal malleolus. Where, however, the deformity is in part or in chief part due to the inward deflection of the astragaloid neck, the division of the ligaments is of much less service.

In these cases, even after the free division of the ligaments (astragalo-scaphoid capsule), the varus has not always been effectually overcome, and we cannot help thinking that when the neck of the bone is thus at fault, a less complete and permanent cure will be obtained. When the neck is deflected inwards, we take it that unless this deformity is dealt with a cure, in the true sense of the word, cannot be obtained; for although, after division of the ligaments, the scaphoid may be rotated outwards on the head of the astragalus, and retained there by apparatus, it seems to us that so long as the neck continues bent, and in consequence the greater part of the head faces inwards, there will always be a tendency for the scaphoid to fall back into the faulty position and for a relapse to occur. In consequence of the shortness of the neck of the astragalus, we do not think that adequate pressure in the direction of rectification can be brought to bear upon it when the astragalo-scaphoid capsule has been divided. We have then no direct pull upon the deflected astragaloid neck. But if we act on the anterior part of the foot before the division of these ligaments, the scaphoid, with the ligaments attaching it to the os calcis and malleolus (astragalo-scaphoid capsule), can be made to press upon the deflected neck, and whilst it is still soft and pliable, as it is in the infant, bend it or force it to take its normal direction. We confess that this objection to syndesmotomy in cases where there is marked inward deflection of the neck of the astragalus may, after all, be only theoretical. Sufficient time has hardly elapsed for us to speak positively as to the number of relapses that occur after its performance, when compared with the number that occur where the ligaments have been left intact and efforts have been made to straighten the astragaloid neck.

When in a dissected specimen of varus the astragalo-scaphoid capsule is divided, and an attempt made to bring the foot into line with the leg, it will be found that, in consequence of the cuboid impinging on the calcis on the outer side of the foot, the scaphoid, as it rolls on the astragalus, is forced away from that bone, leaving a wedge-shaped gap with its base inwards between their articular surfaces. Further, where there is much inward bowing of the os calcis on its long diameter, with overgrowth of bone at its anterior end, the contact of the cuboid with the os

calcis will be found to prevent the complete bringing into line of the foot with the leg, notwithstanding the division of the astragalo-scaphoid capsule.

**Subcutaneous Division of Special Ligaments**—1. *Division of the Ligaments on the Inner Side of the Foot* (*the Astragalo-scaphoid Capsule*).—The term 'astragalo-scaphoid capsule' is applied by Mr. Parker to the dense ligamentous structures uniting the internal malleolus to the scaphoid and os calcis. It consists of a capsule of great strength 'made up above and internally by a blending together of the inferior astragalo-scaphoid ligament with fibres from the anterior ligament and the anterior portion of the deltoid ligament of the ankle-joint; below with fibres from the calcaneo-scaphoid ligament. To these are united fibrous expansions of the tendons of the anterior and posterior tibial muscles. . . . This dense structure,' says Mr. Parker, 'is fortunately quite subcutaneous, and so placed that it can be divided without risk to any other structure.'

*Method of Operating.*—The leg should be laid on its outer side. An assistant, standing opposite the surgeon, should grasp the foot with one hand, and the leg just above the ankle with the other, and, by strongly abducting the foot, should make the ligamentous capsule tense. The surgeon, standing on the outer side of the leg, with his back to the patient, enters the point of the tenotome, held vertically with its cutting edge forwards, immediately in front of the anterior border of the internal malleolus. Having passed the tenotome between the ligament and the skin, which may be gently pinched up by the surgeon's forefinger and thumb to facilitate the passage of the knife, the cutting edge is turned towards the ligament and made to cut through it. The division of the ligament must be continued till the knife reaches the bone, or, rather, enters the subjacent astragalo-scaphoid joint. The point of the knife should be then carried close to the bones, towards the plantar aspect of the foot, to ensure the division of the calcaneo-scaphoid part of the capsule. When the operation is properly performed, the tendons of the tibialis anticus and posticus near their insertion are divided as well as the astragalo-scaphoid capsule. The puncture is closed with the forefinger of the surgeon's left hand, or better by a dossil of antiseptic gauze, and the foot wrenched as far as possible into the normal position. If any

resisting bands are still felt, the tenotome must be reinserted in the puncture and the division completed. 'Should this prove insufficient,' says Mr. Parker, 'to set the foot free, the tenotome may be again introduced just in front of the inner tuberosity of the calcaneum, and the abductor muscle and plantar fascia divided separately or together.' For this operation Mr. Parker recommends a tenotome with a slightly curved blade (Fig. 131), and employs, when several ligaments and tendons are to be divided at the same sitting, an Esmarch's bandage. We have ourselves found the ordinary tenotome sufficient for the purpose, and do not use the Esmarch.

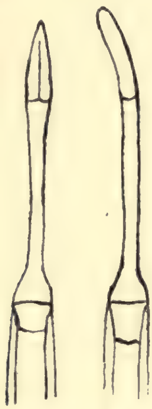


FIG. 131.—PARKER'S TENOTOMES FOR DIVIDING THE POSTERIOR LIGAMENT OF THE ANKLE-JOINT, AND ASTRAGALO-SCAPHOID CAPSULE.

On the completion of the operation, the wound is closed by a small dressing of antiseptic gauze secured with strapping, and the foot and lower third of the leg placed in plaster of Paris for a week (see p. 146).

*Conditions calling for Division of the Astragalo-scaphoid Capsule.*—Practically, the only deformity of the foot for which this operation is required is congenital talipes varus.

*Indications and Counter-indications for the Operation.*—In our opinion, the division of the astragalo-scaphoid capsule is called for in moderate degrees of the deformity in the infant, in which, after division of the tibialis posticus and anticus, the foot cannot be brought into line with the leg, and in which there is no

evidence of much deflection inwards of the astragaloid neck. It is not to our minds necessary or desirable in slight cases in the infant, nor have we found it of any service whatever in severe and in inveterate and relapsed cases in which the child has walked on the deformed foot, and in which the bones are firmly ossified and confirmed in their faulty shape. It should not, we think, be practised in moderate cases in the infant where there is evidence of much deflection of the neck of the astragalus.

2. *Division of the Posterior Ligament of the Ankle-joint.*—The posterior ligament of the ankle-joint is not a very definite structure, and the margins of the bones to which it is attached have a very irregular contour. Hence its complete division with the knife may be impossible. From our experience of the operation, we agree with Mr. Parker that perhaps, as a rule, only the middle portion can be divided; but then, as he says, the remaining fibres can generally be broken down by forcibly dorsal-flexing the foot.

*Method of Operating.*—The division of the posterior ligament may be performed either without or with tenotomy of the tendo Achillis.

(*a*) *Without Division of the Tendo Achillis.*—The patient being placed in the same position as for division of the tendo Achillis—*i.e.*, either on the right or the left side respectively, according as the right or left foot is to be operated on, or on his stomach—the foot should be grasped by an assistant and the ligament made tense by his forcibly attempting to dorsal-flex the foot. The surgeon now passes a Parker's tenotome (a double-edged, spear-shaped tenotome with a rounded shank, Fig. 131) vertically through the tendo Achillis opposite the situation of the ankle-joint. The flat of the blade is held parallel to the fibres of the tendo Achillis whilst it is being passed through that structure. It is then turned with its cutting edges looking outwards and inwards, and is thus passed onwards through the centre of the ligament into the joint. The ligament is now divided as much as practicable on either side of the central puncture, and after the knife has been withdrawn an attempt is made to break down the remaining lateral fibres. The wound is closed in the usual way, and the foot and ankle secured for a week in plaster of Paris or other retentive apparatus.

(*b*) *With Division of the Tendo Achillis.*—The tendo Achillis is first divided in the usual way; the spear-shaped tenotome is then substituted for the ordinary tenotomy knife, and passed through the puncture already made into the posterior ligament, which is divided as far as practicable in the manner described above.

*Conditions for which Division of the Posterior Ligament has been advised.*—(1) For overcoming the equinus condition in congenital talipes varus; (2) for congenital equinus.

We have not ourselves found much benefit follow the division of the posterior ligament of the ankle. The equinus position in many cases of severe congenital varus appears to us to be due to a downward deflection of the neck of the astragalus rather than to any extreme tilting of the trochlear surface of the astragalus out of its socket. In several specimens of severe congenital varus that we have had opportunities of dissecting, we have found that after the free division of the posterior ligament the astragalus could not be brought into such a position as to overcome the equinus of the foot. The division of the ligament permitted the posterior part of the trochlear surface of the astragalus being separated from the articular surface of the tibia; but the bones still locked in front. It appeared to us that in these specimens the astragalus was not in a position of extreme equinus; that is, it was not to any great extent tilted from its socket. The division of the posterior ligament and tendo Achillis allowed the displaced portion of the trochlear surface to be replaced, but this was not sufficient. The neck still had a marked inclination downwards, and the equinus condition of the foot was but very little altered for the better. Over and over again after division of the tendo Achillis, and sometimes of the posterior ligament as well, we have been disappointed in finding that the foot could not be brought up to a right angle, and we believe the reason was the same as shown in our dissections, a downward deflection of the astragaloid neck. In our opinion, these cases can only be cured by acting on the deformed bone, or, if this fails, by a bone operation.

3. *Division of the Anterior Ligament of the Ankle-joint.*—This operation can seldom be required. We have never met with a case where it has seemed to us to be necessary.

*Method of Operating.*—Mr. Parker directs that the tenotome be entered at the anterior border of the inner malleolus, and passed horizontally beneath the extensor tendons and the dorsal vessels and nerve, across the front of the ankle. The foot is then forcibly plantar-flexed by the assistant, and the knife being turned with its cutting edge towards the ligament, the latter, which is very thin, is readily divided. The anterior border of the internal lateral ligament will also be divided simultaneously when the operation is practised in this way.

*Condition that may call for Division of the Anterior Ligament of the Ankle.*—Congenital talipes calcaneus.

4. *Division of the Long and Short Plantar (Calcaneo-cuboid) Ligaments.*—These strong ligaments, which stretch between the calcaneum and the cuboid bone, may be divided as follows: The calcaneo-cuboid joint (which, as stated by Mr. Parker, in congenital varus with much inversion will be found on the outer border of the sole of the foot) having been defined, the tenotome is entered over the articulation. It is then, with its point kept close to the bone, passed across the ligaments towards the inner border of the foot; the assistant now strongly dorsiflexes the foot, and the ligaments having been thus made tense, the cutting edge of the tenotome is turned towards them, and they are divided by cutting towards the bone.

*Conditions calling for Division of the Long and Short Plantar Ligaments.*—(1) Congenital talipes varus; (2) talipes cavus.

We have not personally met with a case in which the division of these ligaments seemed necessary or desirable.

5. *Division of the Internal Scapho-cuneiform and Cuneo-metatarsal Ligaments.*—These ligaments may be divided by introducing the tenotome over the corresponding joint, and cutting towards the bones. Their division is recommended by Mr. Parker in severe cases of congenital talipes varus in which there is much incurvation of the inner border of the foot.

**Open Syndesmotomy.**—For an account of the open method of dividing the ligaments on the inner side of the foot, the reader is referred to Phelps' operation (p. 215). We are not aware that the open division of any of the ligaments of the foot, save those on the inner side of the foot (astragalo-scaphoid capsule), which are divided in Phelps' operation, has been attempted.

(4) **Subcutaneous Division of all the Soft Tissues on the Inner Side of the Sole down to the Bones (Buchanan's Operation).**—Professor Buchanan employs this operation for cases of club-foot in which he thinks the deformity is too severe for milder methods of treatment, as tenotomy, but not sufficiently severe for a bone operation. He has operated in this way in a large number of cases, and claims much success. The cases he thinks most suitable for it are those in which there is so much rigidity of the soft parts that reduction by the hand is practically impossible. He begins the operation by the division of the tendo Achillis; the tendon of the tibialis posticus is divided during the operation.

*Operation.*—The foot having been prepared for operation, a tenotome is introduced subcutaneously at the inner border of the foot opposite the tubercle of the scaphoid, and carried between the skin and plantar fascia, till the point reaches the middle of the sole. The edge is next turned towards the fascia, and this structure, and the underlying soft tissues, muscles, vessels and nerves, are divided in a vertical direction. On reaching the astragalo-scaphoid joint, the point of the tenotome is made to divide the tibialis posticus immediately behind its insertion into the tubercle of the scaphoid, and is then carried through the calcaneo-scaphoid ligament, thus completely freeing the astragalo-scaphoid joint. The internal plantar nerve and internal plantar artery are divided, but their section causes, says Professor Buchanan, no trouble.

We have performed this operation in a few intractable cases of club-foot which seemed to us suitable. At the time of the operation the shape of the foot was certainly much improved, and no apparent harm followed the division of the nerve and artery. We were disappointed, however, with the result, and in one case had subsequently to remove the astragalus. It is possible, however, that the deformity in this case would have been considered by Professor Buchanan as of too severe a grade for his method.

(5) **Subcutaneous Division of all the Soft Tissues in the Sole of the Foot and behind the Internal Malleolus (Lane's Operation).**—This operation is an extension of that of Professor Buchanan. Mr. Lane claims for it that it is the only satisfactory method of dealing with an inveterate club-foot in infancy.

*Operation.*—An Esmarch's bandage having been applied above the knee, a strong long-bladed, sharp-pointed tenotomy-knife is introduced, and all the soft tissues in the sole that oppose moderate abduction of the foot upon the astragalus are divided; namely, the whole of the plantar fascia, part of the internal lateral and annular ligaments, the calcaneo-scaphoid ligament, the long and short plantar ligaments, the tibialis anticus, and all the tendons, muscles, vessels, and nerves in the sole of the foot. Many punctures in the skin have to be made; if any gape they are sewn up, otherwise arterial blood spurts through them on the removal of the Esmarch bandage. The tendo Achillis is next divided, and if the sole does not become square, all the soft parts behind the inner ankle and the posterior ligament of the ankle-joint are also divided. The peronei and the extensor tendons are the only soft parts spared. Even then, says Mr. Lane, in bad cases the skin for a time affords an obstacle to the foot being retained in a good position, and necessitates the use of plaster of Paris for three or four weeks. After the operation the foot and leg are secured on a back splint with a foot-piece, the inner margin of which forms an angle of 25° with the vertical.*

This operation does not commend itself to us. The severance of the whole of the arteries, nerves, muscles, fasciæ and ligaments in the sole of the foot, as well as the whole of the soft parts behind the inner ankle, together with the tendo Achillis and posterior ligament of the ankle, appears to us a very severe, and, we are tempted to say, not a very scientific, procedure. It is one, moreover, that we conceive might readily be attended with unpleasant, not to say serious, complications. However, Mr. Lane does not appear to have had any trouble, and claims that after his operation the patient has a useful foot and walks gracefully.

Relapses, or what we should call imperfect cures, do, however, occur. Such cases have come for further treatment to the Orthopædic Department of St. Bartholomew's Hospital. In these children, in addition to the deformity, there was felt beneath the skin a transverse gap in the muscles, at the bottom of which the

* Lane, *Lancet*, Aug. 19, vol. ii. 1893.

tarsal bones could be felt apparently uncovered by soft tissues except the integuments. It is evident, therefore, that all cases treated by this method are not successful, and it would be interesting to know something of the ultimate condition of the foot in a large number of patients, and the actual proportion of relapses.

We have never performed the operation ourselves, so cannot speak of it personally, beyond what we have seen of cases coming to the Orthopædic Department for further treatment.

(6) **The Open Incision of all the Soft Tissues on the Inner Side of the Foot down to the Bone (Phelps' Operation).**—This operation was proposed, practised, and brought prominently before the profession by Dr. Phelps, of New York.* It consists in making, under antiseptic precautions, an incision on the concave side of the foot through the muscles, tendons, and ligaments, down to the bone. It has now been performed by a number of surgeons in America, on the continent of Europe, and in this country, and may be looked upon as one of the recognised methods of treating certain phases of congenital varus.

Our own experience of the operation has been limited. In the cases in which we have performed it, the foot was certainly greatly improved at the time, but a sufficiently long period has not elapsed for us to say whether the improvement will be maintained. The same may be said of most of the cases that have been reported. We are hardly yet in a position—seeing that we have heard but little of the subsequent history of the patients—to give an opinion as to the ultimate results. We should not ourselves think of resorting to it in slight cases, nor in cases of moderate severity in the infant: such can be cured by less severe methods. Where there is merely moderate displacement of the bones, but practically no alteration in their shape, there is no doubt that the division of the tibial tendons and short ligaments on the inner side of the foot is successful in restoring the symmetry of the foot. But such an end can be equally well attained by ordinary subcutaneous tenotomy or syndesmotomy of the astragalo-scaphoid capsule, or even by plaster of Paris or mechanical appliances.

For severe cases, where the above-mentioned procedures are insufficient, and in such only have we employed Phelps'

* *New York Medical Record*, September 24, 1881.

method, there appear theoretical objections which time alone, by showing that they are merely theoretical and not of any practical value, can prove. Thus the division of the tense structures on the inner side of the foot (although in many cases, probably the majority, it undoubtedly allows of the tarsal bones beneath and in front of the astragalus being wheeled round on the latter bone in an outward and upward direction) does not correct the inward and downward deflection of the neck of the astragalus, and the inward curve in the long axis of the os calcis.

The condition of the parts after the operation appears to us somewhat analogous to what occurs in knock-knee after division of the external lateral ligament and tendon of the biceps. Here, after the division of these structures, the tibia can be brought into line with the femur, but it is only at the expense of a partial separation of the articular surfaces. The so-called down-growth of the inner condyle and uprising of the inner tuberosity of the tibia remain untouched, and on leaving off the correcting mechanical appliances the limb relapses again into a condition of genu valgum.

In Phelps' operation it is true that the articular surfaces are not separated quite in the same way as after division of the external lateral ligament and biceps in knock-knee—at least, as regards the articulation of the scaphoid with the astragalus; but as regards the cuboid and os calcis it appears to us, inasmuch as the plane of the cuboidal facet on the latter bone looks in the talipedic foot forwards and inwards, that if the cuboid is carried into a line with the leg, it must be at the expense of the separation of the contiguous articular facets on their inner side. Moreover, from dissections we have made, we are not so sure that the correction after Phelps' operation is due to a mere sliding of the scaphoid round the astragalus, since we found that rectification in the dissected foot after division of the short ligaments and tendons on the inner side was here only accomplished by the actual separation of the articular surfaces. It appears to us, therefore, possible, if not probable, seeing that the deformed shape of the bones is not touched, that there must be a tendency, in these severe cases, for the bones in front of Chopart's joint to become drawn again into their faulty position as the soft

tissues on the inner side of the foot cicatrize and contract. We repeat that we offer this only as a theoretical objection. Our own cases will be kept under observation, and the ultimate results given when sufficient time has elapsed to make their publication of value.

Mr. Lane* says, in speaking of his cases, operated on by Phelps' method, that, notwithstanding the foot remains flat, the result when the patient begins to walk is very unsatisfactory, since there is a total loss of continuity of all the soft parts of the sole of the foot. He has never himself attained by this method a result with which he was satisfied, nor has he seen one.

It is a question whether the tendo Achillis should be divided at the same time that the open incision on the inner side of the foot is performed. Dr. B. E. Mackenzie,† of Toronto, reports a series of cases treated by Phelps' method, and comes to the conclusion that it is better to delay division of the Achillis tendon till the wound on the inner side of the foot has healed. In his cases he does not seem to have been able to get the foot up to, or at any rate beyond, a right angle. And this is what we should be led to expect. For, as we have endeavoured to show elsewhere, the equinus position is certainly in some cases due, not, as has been generally taught, to the mere tilting of the astragalus partially out of its socket, but to a downward deflection of the astragaloid neck; so that even after division of the tendo Achillis and posterior ligaments, and the replacement of the astragalus in its socket, the equinus position still remains, and can only be effectually overcome by the division or the gradual bending of the neck itself. Phelps' operation theoretically is insufficient to overcome this difficulty. From the perusal of Dr. Mackenzie's cases it would seem, moreover, to be insufficient in practice.

*The Operation.*—An Esmarch's bandage having been first applied, an incision is made from about half an inch in front of the internal malleolus vertically downwards for about two inches over the concave inner border of the foot. It will thus extend across the inner two-thirds of the sole. After cutting through the

* *Lancet*, August 19, 1893.

† Mackenzie, B. E., 'Transactions of American Orthopædic Association,' vol. iv., p. 41.

superficial and deep fascia with probably some fibres of the internal fasciculus of the plantar fascia, the abductor hallucis muscle is exposed. This is carefully divided, and the internal plantar nerve and artery sought for beneath it and hooked aside. The tendon of the tibialis posticus, and in the upper part of the wound the tibialis anticus, are next cut through, and then the internal lateral ligament and calcaneo-scaphoid ligament, *i.e.*, the astragalo-scaphoid capsule, till the head of the astragalus is exposed. The foot is then forcibly wrenched into the best possible position. The wound, which gapes in consequence of the deficiency of skin on the inner side of the foot, is stuffed with some antiseptic material and allowed to granulate. The foot is placed in the rectified position on a splint, or in plaster of Paris with a window cut in it for the purpose of dressing the wound.

The tendo Achillis is usually divided at the end of the operation. The operation has been modified by the numerous surgeons who have performed it both as regards the direction of the skin incision and the structures subsequently divided. Briefly, it may be said that all resisting tissues are cut through, till the foot can be placed as nearly as possible in the normal position. Thus, in addition to the structures already mentioned, the flexus longus digitorum and the flexor longus hallucis may have to be divided where they cross the sole, as may also the long calcaneo-cuboid ligament; but this ligament does not as a rule offer any resistance to reduction. By some surgeons, tenotomy of the tendo Achillis is advised before the operation, instead of at the end.

The aim of the operation being to lengthen the inner border of the foot, the filling up of the wound by granulations is prevented as far as possible, and healing is allowed to take place by the skin spreading down the side of the wound. Lane* has hastened the healing of the wound and prevented the subsequent extensive cicatrization by changing the dressings on the second day and applying a large skin graft over the whole of the raw surface, taking care to make the graft large enough to allow for the shrinkage which always takes place in it.

(7) **Section and Excision of Certain of the Tarsal Bones.**—It is

* *Lancet*, August 19, 1893.

only since the days of aseptic and antiseptic surgery that operations on the bones for correcting club-foot have been at all generally undertaken. In 1854 Mr. Solly, at the suggestion of Mr. Little, removed the cuboid in an inveterate case of varus in the adult; but the operation met with little favour, and it does not seem to have been again performed till undertaken by Mr. Davy in 1874. Two years later Mr. Davies-Colley removed a wedge-shaped portion of bone from the tarsus, an operation which was subsequently taken up by Mr. Davy, by whose name the operation is, perhaps, generally known. In 1872 Mr. Lund removed the astragalus (Lund's operation). In more recent times various other operations and modifications of those above mentioned have been practised on the tarsus, such as the division of the tarsus with a chain-saw; the section of the neck of the astragalus with a chisel; the resection of the head of the astragalus; the resection of the external malleolus and part of the os calcis; the removal of two or more of the tarsal bones, or, with the exception of the os calcis, of the whole of the tarsal bones. The division of the tarsus, or of certain of the bones entering into it (tarsotomy), the excision of a wedge from the tarsus (tarsectomy), and the removal of the astragalus (astragalectomy), are now well-recognised surgical procedures for the treatment of inveterate cases of club-foot, and will be dealt with in detail. Recently, Dr. Fitzgerald, of Melbourne, has performed an operation consisting of a combination of division and crushing of the tarsal bones. For the correction of the inward rotation of the whole limb Hahn has proposed a linear osteotomy of the tibia and fibula, just above the malleoli, with a twisting of the whole foot outwards; whilst Mr. Parker and others have practised Macewen's operation, with rotation of the limb below the section of the femur for the purpose of correcting the eversion.

*Tarsotomy*.—The operation of tarsotomy consists in cutting across the tarsus either with chisel or saw, and in then forcibly bringing the part of the foot in front of the cut through the tarsus into as good a position as it can be made to assume. We have performed this operation on several occasions where milder measures have failed to rectify the foot, but as a rule have been disappointed with the result. The simple division of the tarsus was not found sufficient to allow of satisfactory rectification, and the

operation begun as a tarsotomy had to be completed as a tarsectomy by making a second cut across the tarsus, and then removing a wedge-shaped piece of bone having its base upwards and outwards. Linear tarsotomy, however, is highly spoken of by Mr. Symonds, of Oxford. He divides the tarsus with the chain-saw, the instrument we have ourselves used.

*The Operation.*—The foot having been prepared in the manner already stated, a vertical incision is made on the outer side over the most prominent point of bone, and a second incision on the inner side opposite to the first. The extensor tendons, and the anterior tibial artery and nerve, and other soft structures, are next separated from the bones by means of a periosteal elevator, the foot being dorsal-flexed as much as possible to relax the parts. The elevator must be introduced first through the one incision and then through the other, and should be kept close to the bones whilst separating the soft tissues, otherwise the one tunnel may not strike into the other, and some difficulty may be experienced in passing the probe beneath the tendons for the conveyance of the chain-saw. The probe should be slightly curved, and be threaded with a portion of aseptic silk, to which is fixed the terminal loop of one end of the chain-saw, the handle of course being removed.

When the chain-saw has been got into position the guide silk is removed, the handle adjusted, and the saw worked downwards through the tarsus, with the hands well depressed below the level of the foot to prevent the top of the saw bruising more than can be helped the raised-up soft tissues. An assistant should have charge of the incisions, and prevent the skin, by means of retractors, from being lacerated by the saw. If there appears any danger of this, it is better to prolong the skin incisions downwards than to leave a wound with jagged edges. As soon as the bones are felt to have been cut through, the saw should be removed, the wound well syringed out with perchloride of mercury lotion or other antiseptic, the foot rectified as far as possible, the wounds completely closed by suture, and the foot wrapped in a plentiful supply of antiseptic gauze and wool, and enclosed in its improved position in a plaster of Paris bandage. If care has been taken to prevent septic infection the bandage may be kept on till the wound has healed. We have usually

removed it in three weeks or a month after the operation. It is only for cases of moderate severity that we have found the operation sufficient for the purpose of rectifying the foot. Severe cases, in our experience, require either the removal of a wedge-shaped piece of the tarsus or the ablation of the astragalus. Such cases as appear to us suitable for this method are, we contend, better dealt with by some less severe procedure, such as free division of the ligaments subcutaneously.

*Tarsectomy* consists in removing a portion of the tarsus. Many forms of tarsectomy have been proposed; the excision of a wedge-shaped piece of the tarsus (Davy's operation), and the removal of the astragalus (Lund's operation), are the operations usually performed. These only will be described.

*Excision of a Wedge from the Transverse Tarsal Joint* (*Davy's Operation*).—This operation consists in removing a double wedge-shaped piece of bone, the apex of one wedge being downwards and the other inwards. The bone removed consists of a portion of the cuboid and os calcis on the outer side, and of a smaller portion of the astragalus and scaphoid on the inner side. Mr. Davy, who has perhaps worked most at this subject, advises that a cast of the foot in the deformed position should first be taken, and then from the plaster model a sufficiently large wedge removed to restore the shape of the foot. Having thus accurately determined on the model how much bone must be excised, he then so plans his incisions on the living foot that the portion of the bones removed on either side of Chopart's joint shall correspond in size and shape to the wedge removed from the plaster model.

Where the varus position is the most marked feature of the deformity, and the astragalus is not much tilted out of its socket, and the inward and downward deflection of the astragaloid head and neck is chiefly at fault, the operation of removing a double wedge is, as a rule, preferable to astragalectomy. In very severe cases, however, neither operation alone may be sufficient. We have frequently, after removing a wedge, had to remove the astragalus also, either at the same operation or subsequently. And the same may be said where the astragalus has been first dealt with. Either at once or at a later period we have had to take away more bone before a satisfactory restoration of the foot could be accomplished.

*The Operation.*—The foot having been carefully prepared in the way already mentioned (p. 186), and the Esmarch's bandage applied before the preliminary antiseptic dressing is removed, an incision in a horizontal direction over the prominent outer border of the foot is made. The length of the incision will vary according to the size of the foot and the amount of the deformity. As a rule, an incision about an inch and a half long, say, in a child of seven or eight years of age will suffice; but it is better to make it too long than to bruise the soft tissues in the subsequent steps of the operation through not having sufficient room. A vertical cut for half an inch to an inch downwards towards the sole, making the incision T-shaped, will be found of advantage in the severer grades of the deformity. A second and smaller horizontal incision, about half an inch long, is next made on the inner and concave border of the foot opposite the centre of the incision on the outer border. Through these incisions, which should be made down to the bones, periosteal elevators are introduced and the tendons and other soft structures carefully raised from the underlying bones. The elevator should be kept as close to the bones as possible, so as to ensure the thorough separation of the soft tissues; Mr. Davy divides the bones by passing beneath the tendons his triangular director, and working in the grooves on its two arms an Adams' saw. We have used this instrument in some cases, but as a rule pass the chain-saw in the way described in the operation of tarsotomy. The bones having been cut through so as to detach a double wedge-shaped portion, the wedge is seized through the external incision with sequestrum forceps, and removed in one piece. An attempt should be now made to bring the foot into the normal position; if on doing so it is found that the bases of the double wedge have not been made sufficiently large to allow of the complete overcoming of both the varus and equinus positions, a further wedge-shaped slice should be removed with the saw from either the proximal or distal bones, according as, on inspecting the wedge, it is found that more of the scaphoid and cuboid on the one hand, or more of the astragalus and os calcis on the other hand, has already been excised.

In removing another slice from the astragalus, care should be taken not to go so far backwards as to endanger opening the

ankle-joint. If the foot cannot yet be restored, a second, and if necessary a third, slice must be taken away. Our rule has been, having once embarked on a bone operation, to take away sufficient bone to accomplish the objects for which the operation was undertaken, namely, the placing of the foot at a right angle to the leg, overcoming the inversion, and obtaining a plantigrade sole. In the most severe case with which we have had to deal, after removing a wedge from the tarsus consisting of nearly the whole of the scaphoid, half of the cuboid, the head and neck of the astragalus, and a large slice from the anterior end of the os calcis, it was found that no appreciable improvement was obtained. The remainder of the astragalus, cuboid and scaphoid, and the anterior third of the os calcis, were then taken away, but it was not till the cuneiform bones and bases of the metatarsals, with a portion of the external malleolus, had been removed, that the above-mentioned desiderata were obtained. And we had no reason to regret what may perhaps be thought a somewhat heroic procedure. The foot in the end, though of course shortened, became a very useful member, and the patient was so pleased with the result that he walked, with a crutch for the other foot, some 160 miles to have a like operation performed on the opposite side. This was, of course, an extreme case, and one not likely to be met with twice in a lifetime.

When enough bone has been removed to satisfactorily restore the foot, the wound should be well irrigated with perchloride of mercury (1 in 2,000); any loose shreds or bruised portions of tissue carefully cut away with curved scissors; the incisions brought together with sutures; the wound dressed with a plentiful supply of gauze and wool; a cotton-wool bandage wound over the foot and leg, and a plaster of Paris bandage applied sufficiently tightly to exercise firm pressure on the wound. In our later operations we have used no drain. Formerly, a small piece of pewter wire was inserted through the outer wound; but this has been found quite unnecessary and to some extent a disadvantage, in that it necessitates a disturbance of the healing process for its removal, and if left in till the rest of the wound has healed causes a sinus. We have usually left the plaster bandage on from three weeks to a month, and at the end of that time have generally found the wound healed. On the removal of the

plaster, massage and passive movements should be sedulously employed.

*Astragalectomy, or Lund's Operation.*—The removal of the astragalus for the cure of intractable cases of club-foot was first proposed and performed by Mr. Lund, of Manchester. It should only be done in intractable cases, and after milder measures have been perseveringly tried and have failed. It is especially applicable to those cases in which the neck of the astragalus is more than usually deflected inwards and downwards, and the foot in consequence cannot be brought up to a right angle. But the removal of the astragalus is often alone insufficient in these severe cases to allow of the foot being brought into normal relations with the leg. After the bone has been excised, the foot will still not come up to a right angle with the leg, the anterior end of the os calcis coming into contact with the external malleolus. This locking of the bones may be overcome by removing the anterior end of the os calcis. At other times the external malleolus may have to be removed, or the external malleolus cut across just below the articulation of the fibula with the tibia, and then bent backwards and outwards to allow the os calcis to come up. Division of the tendo Achillis in severe cases improves matters a little, but as a rule, when the foot cannot be placed at a right angle with the leg, it is due to a locking of the bones, and not to a shortened condition of the tendo Achillis. In some instances, the removal merely of the head and neck of the astragalus, without opening the ankle-joint, and perhaps the anterior end of the os calcis also, will be sufficient to restore the shape of the foot.

*The Operation.*—We have always removed the astragalus by Lund's method, *i.e.*, by a single external incision over the bone, between the peroneus brevis and tertius. The advantages of this method are that no tendon is divided, a good exposure and plenty of room is obtained, no named vessel or nerve or other important structure is interfered with, and on the healing of the wound a single linear scar only remains. Moreover, it admits of the removal of further portions of bone, if such be found necessary, after the ablation of the astragalus.

The foot having been previously rendered aseptic and an Esmarch's bandage applied over the antiseptic dressing, which should not be removed till the patient is on the operating table,

an incision is made about two inches in length over the prominent convex outer border of the foot, from the tip of the external malleolus downwards and forwards over the prominence of the astragalus between the peroneus brevis and tertius. The incision should extend directly to the bones. The soft tissues, with the extensor tendons, should now be raised, keeping the elevator close to the bone, and the ankle-joint and astragalo-scaphoid joint opened so as to define the position of the astragalus. The ligamentous attachments along the under border of the external surface of the astragalus should next be divided by continuing the incision between the scaphoid and the astragalus downwards and backwards to the external malleolus. The knife should then be carried round the anterior border of the external malleolus, dividing some of the fasciculi of the external lateral ligament. The foot should be now well adducted, and the interosseous ligament between the astragalus and os calcis divided either with a narrow bladed knife or, better, with slender bone-scissors. This and the next step of the operation, namely, the division of the internal lateral ligament, will be facilitated by introducing an elevator between the astragalus and the adjacent bones, so as to prise the bones somewhat apart, and permit of the introduction of the bone-scissors. The only difficult part of the operation is the division of the internal lateral ligament. This will be rendered easier if the astragalus is seized with lion-forceps, and drawn now this way and now that, as the remaining fibres are divided.

At the end of the operation the wound may be safely closed with sutures, and, if all antiseptic precautions have been taken, the foot may be put up in plaster of Paris, and thus left till the wound has healed. The Esmarch's cord should not be removed till the dressings have been applied and the plaster has firmly set. We have usually dressed the wound for the first time at the end of the month. Passive movements should then be sedulously employed to ensure fibrous ankylosis and a fair amount of mobility at the ankle. From 1882 up to 1893 there had been performed at St. Bartholomew's Hospital twenty-one cases of astragalectomy for talipes. Sixteen of these cases were under the care of Mr. Walsham, the remainder under the care of Mr. Willett. All did

well. In only two, and these among the earlier cases, was there any suppuration.

What is the ultimate condition of the foot after removal of the astragalus, and, if necessary, of other portions of the tarsal bones? Clearly it is an imperfect member. It must be so; but it is a much more useful and sightly one than when the deformity is allowed to remain untreated, or has been only partially rectified by milder measures. The foot is plantigrade and respectable in shape, and if healing by the first intention is ensured and passive movements are subsequently kept up, a fairly movable ankle-joint is obtained. Further, the patient's walking power is much improved, and he can, as a rule, dispense with instruments. We say as a rule, because the severe deformity of the foot that calls for astragalectomy is, after all, often merely part of a general malformation of the whole limb, the muscles being wasted, the knee-joint loose, and the neck of the femur perhaps so deflected that the whole leg turns inwards. For some cases, therefore, the long-continued use of instruments reaching to the waist (p. 231) is necessary. Where instruments, on account of the expense, cannot be obtained, an osteoclasia or osteotomy of the femur, with rolling of the lower fragment with the leg outwards, will be of service.

(8) **A Combination of Tenotomy, Syndesmotomy, and Division and Crushing of certain of the Tarsal Bones (Fitzgerald's Operation*).**—An Esmarch's bandage having been applied, the tendo Achillis at its insertion, the tibialis anticus above the ankle, and the tibialis posticus, are subcutaneously divided. The plantar fascia, the abductor hallucis, the calcaneo-scaphoid ligament, and, if necessary, the anterior fibres of the deltoid ligament—in short, all resisting structures on the inner side of the foot down to the astragalo-scaphoid articulation—are next severed. The internal plantar artery and nerve are necessarily cut across. A chisel, with its cutting edge bevelled like a V, with a round stem of uniform size and long enough to be grasped by the hand, is next introduced through a valvular incision in the skin on the outer side of the foot just behind the calcaneo-cuboid articulation. With the chisel the neck of the astragalus is severed from the

* Fitzgerald, 'A New Procedure for the Cure of Congenital Talipes Varus and Equino-varus.' Melbourne: Stillwell and Co., 1889.

body of the bone; the scaphoid is now freely broken up subcutaneously with the chisel, and the os calcis is divided obliquely just behind the posterior articular surface for the astragalus into two equal halves. The cuboid is drilled in a few places to 'help nutrition.' The foot having been now forcibly moulded into a normal shape, and any prominent fragments of the scaphoid 'hammered back' into place, it is rolled in antiseptic wool, and firm pressure applied from the toes to the knee. The limb is next secured to a splint provided with a ball-and-socket joint beneath the foot-piece, and controlled by a screw.

Fitzgerald reports twenty cases operated on by him by this method in one year, and claims excellent results. We have had no practical experience of it ourselves,* nor do we know of any cases of club-foot that have been so treated in this country.

In concluding our description of these various severe operations on the tarsus, we would repeat that they should never be undertaken till milder measures have been tried and failed. They should be reserved for intractable, relapsed and uncured cases.

**After-treatment.**—When the foot has been rectified, or rectified as far as possible, by the employment of some or other of the methods already described in detail under the heads of manipulative, mechanical and operative treatment, further mechanical after-treatment is, as a rule, necessary to prevent a relapse. Whilst employing such mechanical treatment, however, the surgeon should not lose sight of the fact that the mechanical appliances thus used are not in themselves sufficient for this purpose. Their use is merely to retain what has been already gained until by efficient physiological after-treatment the nutrition of the muscles has been so far improved, the articular facets so far consolidated, and the function of the rectified foot so far restored, that a relapse is no longer to be feared.

The after-treatment will be considered under the heads of (1) mechanical after-treatment; and (2) physiological after-treatment.

(1) **Mechanical After-Treatment.**—Very numerous are the con-

* This was written before Mr. Kent Hughes left for Melbourne.

trivances that have been invented for the purpose of retaining the foot in the corrected position. They may be divided into (1) instruments for use during the night, and (2) instruments for use during the day. The former consist of some form of splint, and are designed for preventing the tendency of the weight of the bedclothes to press the foot back to its deformed state. The latter, which are composed of boots with leg-irons reaching, in some instances, to the pelvis, are so made as to allow the patient to walk. They should be as light and as little unsightly as possible, readily adjustable by the mother or nurse, and should not impede the free movements of the foot and limb.

1. *Instruments for Use during the Night.*—In the recently

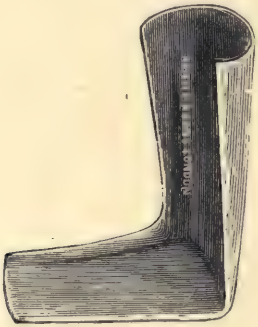


FIG. 132.—TIN RECTANGULAR VARUS NIGHT-SHOE.

corrected foot, there is always a tendency for the weight of the bedclothes to press back the foot towards the deformed position; to prevent this a bed-shoe should be worn, or if the foot has not been completely rectified, the apparatus used for correcting purposes should still be worn at night. We employ the simple tin splint shown in the accompanying diagram (Fig. 132). It consists of a calf-piece for the back and outer side of the calf, and of a foot-piece, bent at right angles to the calf-piece, and turned up on the inner side so as to prevent the foot rolling inwards. An oval hole is placed opposite the internal malleolus to prevent pressure at this spot. The splint is softly padded, and covered with wash-leather. It is secured to the foot by a few turns of a domett bandage. The bandage should be fastened to the splint with safety

pins at each end to prevent the child kicking the splint off during the night. The splint should be worn for, at least, twelve to eighteen months.

2. *Instruments for Use during the Day.*—These may be divided into (A) those that have merely for their object the holding of the foot in the restored position; (B) those which, in addition to this object, are designed to overcome the tendency of the whole limb to roll inwards; and (C) those which have for their purpose still further improvement of the but partially rectified foot.

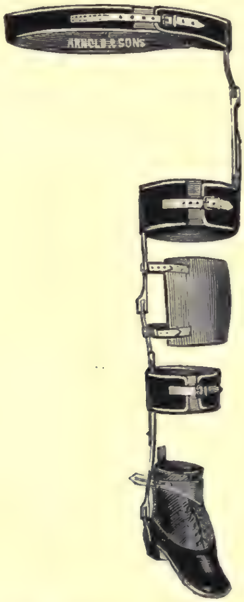



FIG. 133.—BOOT WITH VARUS T-STRAP, INSIDE LEG-IRON AND OUTSIDE THIGH-IRON.

The leg-iron is continued above the knee to a thigh-circlet, and from the outer side of the thigh-circlet above the hip to a pelvic band.

A. *Instruments having for their Object the Holding of the Foot in the Restored Position.*—When the foot has been satisfactorily restored, that is, when the varus has been completely overcome, and the foot can be dorsal-flexed well beyond the right angle, say to thirty degrees with the leg, and there is no relaxation of the

knee-joint with rolling in of the leg or rolling in of the whole limb from the hip, we employ the simple apparatus shown in Fig. 134 (A). It consists of a well-made and properly-shaped boot to which is fixed an inside leg-iron and varus T-strap. The leg-iron is provided with a free joint corresponding to the ankle, and is fixed to the leg just below the knee by a simple calf-circlet. This boot should be worn for twelve months, or until the foot shows no tendency to relapse. The night-shoe shown at p. 228 should be worn for the same time at night, and the exercises described under physiological after-treatment should be sedulously employed.


FIG. 134.—(A) BOOT WITH INSIDE LEG-IRON AND VARUS T-STRAP. (B) BOOT WITH INSIDE AND OUTSIDE LEG-IRONS AND VARUS T-STRAP.

Some surgeons use a boot and iron with an anterior stop-joint at the ankle, with the object of counteracting any tendency to recontraction of the tendo Achillis. Others, to prevent a return of the inversion, employ an outside leg-iron, or steel spring, or an outside as well as an inside leg-iron (Fig. 134, B).

B. *Apparatus having for its Object not only the Maintenance of the Foot in its Improved Position, but also the Controlling of Inversion of the Limb.*—When the foot has been thoroughly rectified, it is often found that, on the child beginning to walk, the

toes still point inwards. This may be due to laxity of the ligaments of the knee-joint allowing the tibia to roll inwards on the femur, but more often to the whole lower limb rolling in at the hip-joint in consequence of a faulty direction of the neck of the femur. When merely the result of laxity of the ligaments of the knee, the pointing inwards of the foot can at times be controlled by carrying the leg-iron or irons above the knee and fixing it or

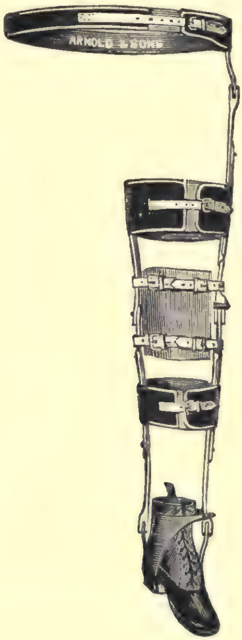



FIG. 135.—WALKING APPARATUS WITH OUTER IRON CARRIED TO PELVIC GIRDLE. The T-strap should be on the outer side.

them to a thigh-circlet. When the whole limb rolls in at the hip, the outer iron must be carried above the hip-joint and there secured to a pelvic band (Figs. 133 and 135). In our experience, it is seldom that the rolling in of the toes depends solely on laxity of the ligaments at the knee, and even when this condition may be the chief one at fault we have obtained better results in controlling it by carrying the outer iron to a pelvic band.

The apparatus, therefore, we commonly use, consists of a boot with double leg-irons below the knee, or in some instances carried above the knee (Fig. 135), and of an outer iron continued to the pelvis. The leg-irons are fixed in the heel of the boot in the way to be presently mentioned, and are secured to the leg on either side of which they lie by a calf-circlet immediately below the knee. Corresponding to the situation of the ankle, each iron has a free joint.

The inner iron stops at the inner side of the calf-circlet just below the knee. The outer iron is continued to a pelvic girdle, and has a free joint at the knee and hip, and is secured to the thigh by a thigh-circlet just above the knee. When the inner as well as the outer iron is carried above the knee, it terminates on

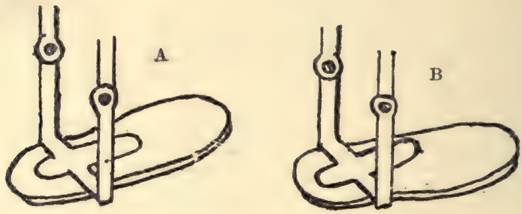



FIG. 136.—LEG-IRONS IN THE ROUGH, SHOWING HOW THE IRONS MAY BE PERMANENTLY FIXED IN THE BOOT, AND HOW EVERSION OF THE FOOT CAN BE OBTAINED BY SHIFTING THE INNER IRON, WHICH IN *A* IS OPPOSITE THE OUTER IRON, BACKWARDS, AS SHOWN IN *B*.

the inner side of the thigh-circlet, and, like the outer iron, has a free joint at the knee. The thigh and the calf-circlets consist of thin bands of iron about an inch to an inch and a half wide. The calf-circlet is riveted to the outer and inner iron just below the knee, and passes in the form of a half-circle behind the calf. In front the circlet is continued in the form of a strap from the inner and outer irons, and buckles in front. The posterior iron-half as well as the anterior strap-half of the circlet is well padded and covered with soft leather. The calf-circlet should be situated immediately below the internal tuberosity of the tibia on the inner side and the head of the fibula on the outer side, so as just to clear these points of bone. If placed higher, chafing of the skin and sores are liable to occur. The thigh-circlet is formed in the

same way as the calf-circlet. It should be placed a little above the knee.

The requisite amount of eversion of the foot is obtained by fixing the inner iron to the heel of the boot behind the spot at which the external iron is fixed, as is explained by the diagrams (Fig. 136). When the instrument is applied to the leg and the irons are parallel to the sides of the calf, the inner iron being attached

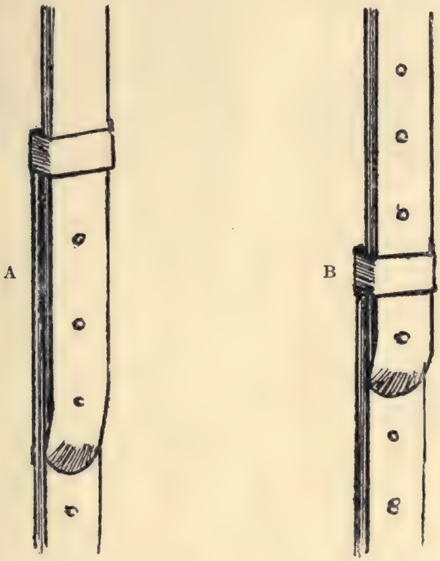



FIG. 137.—METHOD OF LENGTHENING IRONS TO REGULATE THEM TO THE GROWTH OF THE CHILD.

A, When first applied; B, when lengthened to full extent.

to the boot behind the outer necessarily causes the foot to be everted. The irons are commonly fixed in the boot by bending them inwards and outwards respectively, at a right angle, so that the bent ends meet beneath the heel of the boot. Here they are welded together and hammered out so as to take the form of a thin sole-plate as shown in Fig. 136. The hammered-out longitudinal portion is fixed between the layers of leather forming the sole of the boot by rivets, not parallel with the sides of the sole,

but obliquely, according to the necessary amount of eversion required.

But to make sure of having the required eversion and no more, the boot should be tried on in the rough before the sole is completed; the inner iron can then be readily shifted either forward or back-

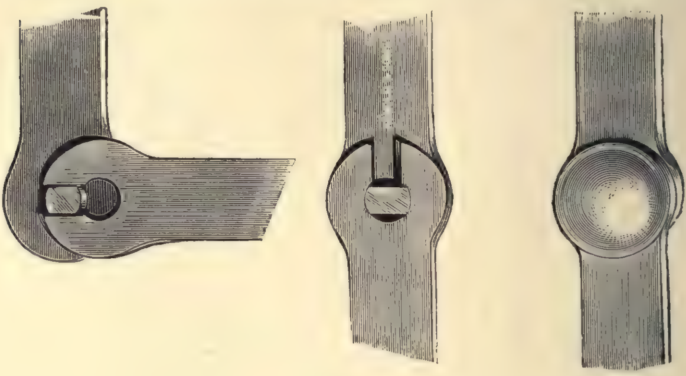


FIG. 138.

ward by removing the rivets in the hammered out sole-plate and re-inserting them when the irons have been adjusted to the position required.

FIG. 139.

Eversion of the whole limb is secured by fixing the outer iron to the pelvic girdle, with its external face looking obliquely outwards and backwards.

To allow for the growth of the child, both the leg-irons and the thigh-iron are made of two portions, each portion overlapping the other as shown in Fig. 137, and secured each to each by sliding clamps and screws. As the leg and thigh increase

in length, the respective iron is also increased in length by removing the screws, sliding the upper portion on the lower, and fixing the screws in the higher and lower holes respectively. By this simple contrivance the irons can be lengthened several inches, half an inch to an inch at a time, according to the rate o growth of the child.

For the purpose of changing the boot without necessarily removing the whole instrument, the joints at the ankle may be constructed in the way shown in the accompanying diagram (Fig.

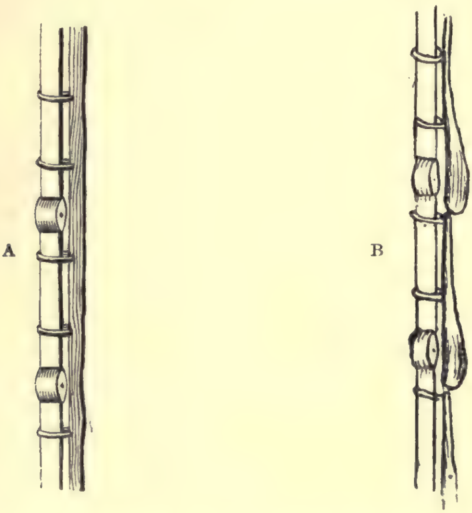



FIG. 140.—ARRANGEMENT OF THE PADDING OF THE LEG AND THIGH IRONS. (A) Faulty method. (B) Improved method.

138). The pivot of the joint is of such a shape that when the portion of the leg-irons below the ankle-joint is at a right angle to the portion above the joint, the lower portion with the boot can be removed, while when in the walking position the joint is secure.

Another contrivance for permitting the boot to be removed without taking off the whole instrument is for the irons to fit into a square socket in the heel of the boot (Fig. 139). The objection to this plan, however, is that in use the sockets soon become

too large for the irons, and the irons in consequence are continually liable to slip out. Fixing the irons when loose with a strap is not satisfactory; so when a removable boot is desired, we generally make use of the former method.

In the padding of the irons there is a matter of detail of some little importance. If the padding is composed of a continuous piece reaching from the pelvic band to the boot as shown in Fig. 140 (A), it will ruck opposite the situation of the hip, knee, and ankle when these joints are bent. To obviate this, the padding should consist of three pieces, one for the iron above the hip-joint, one for the iron between the hip and knee, and one for the

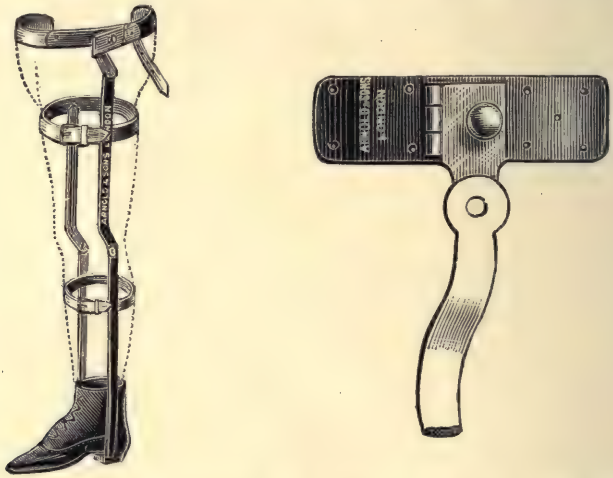


FIG. 141.—BONNET'S APPARATUS FOR EVERTING THE LIMB AFTER CURE OF CLUB-FOOT. (After Rédard.)

iron between the knee and ankle, as shown in Fig. 140 (B). A glance at the illustration will make it clear that, when thus arranged, the padding will not ruck in the movement of the various joints, so avoiding the rubbing and chafing of the skin of the parts which are in contact with the pads.

Amongst other forms of apparatus for everting the foot and limb may be mentioned the following:

*Bonnet's Apparatus.*—In this the eversion of the limb is provided for by the thigh-iron being fixed to the pelvic girdle by a

hinge which can be regulated by a pressure-screw (Fig. 141). As the screw is turned, the plate of steel to which the thigh-iron is


Fig. 142.—Mathieu's Apparatus for producing Eversion of the Limb. (After Rédard.)

attached is moved outwards at the hinge on the pelvic girdle, and so rolls out the whole of the limb.

Fig. 143.—Rédard's Method of producing Eversion.

*Mathieu's Apparatus.* — Mathieu, in place of a pressure-screw, employs a transverse lever fixed to the back of the

pelvic girdle. Its action will be seen on referring to the plate (Fig. 142).

*Rédard's Apparatus.*—Rédard uses the mechanism shown in Fig. 143 for everting the thigh- or leg-iron. It is simply a socket receiving a pin, which can be fixed by a screw in the required position of eversion.

*Doyle's Apparatus.*—Doyle employs a spiral spring in the thigh- and leg-irons. He also uses a spiral spring to the boot (Fig. 144).

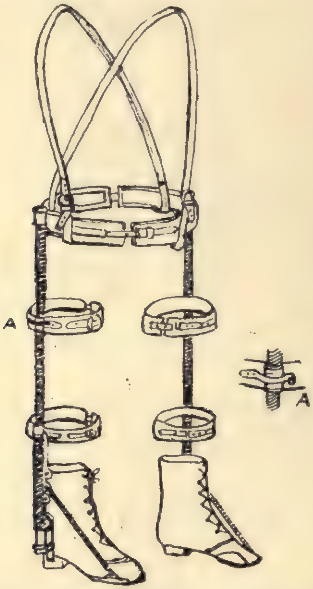



FIG. 144.—DOYLE'S APPARATUS FOR CORRECTING INVERSION OF THE LIMB AFTER CURE OF CLUB-FOOT.

*Meusel's Apparatus.*—To overcome inversion of the foot and knee, Meusel has a sliding arrangement in the thigh-circlet, so that the leg-irons can be rotated outwards at this situation, and thus fixed by a screw. The thigh-circlet is fixed by a thigh-iron to the pelvic girdle (Fig. 145).

*Sayre* recommends for double varus, with turning in of both limbs, the use of a steel rod attached to the front of the soles of both boots in such a way as to allow motion in all directions,

whilst the heels are secured to each other by a chain shorter than the rod. Thus each foot serves to rotate the other outwards.

FIG. 145.—MEUSEL'S APPARATUS FOR CORRECTING THE INVERSION OF THE FOOT AND LEG AFTER THE CURE OF CLUB-FOOT. (After Hoffa.)

We have not used this apparatus ourselves, since it seems to us that it would greatly impede the walking of the child, but as a

FIG. 146.—SAYRE'S APPLIANCE FOR CORRECTING INVERSION IN DOUBLE CLUB-FOOT.

temporary expedient we can conceive that it is a useful method of compelling eversion. (Fig. 146.)

c. *Apparatus having for its Purpose the still further Improvement of the but Partially Restored Foot.*—The apparatus here described is used when the correction of the foot has not been complete, for the purpose of still further improving the foot. As a rule, we should not resort to mere retentive apparatus till the cure is complete. Cases are met with, however, in which it is desirable to allow the patient to walk before the foot has been quite corrected by methods necessitating his lying up; and other cases occur in which, after months of treatment, the foot still cannot be said to be completely cured. For such some form of apparatus is required that will allow the patient to walk, and, whilst preventing a relapse, will at the same time have a

FIG. 147.—BEELY'S BOOT FOR FURTHER CORRECTING EQUINUS.

tendency to further improve the position of the foot. Such apparatus may be considered under (1) that used to overcome the equinus position alone, and (2) that designed to overcome the varus as well.

(1) *Apparatus for Retaining the Foot in the Improved Position and for further Correcting the Equinus.*—Many forms of such apparatus have been invented. The principle underlying them all is the application of elastic force, acting on the anterior part of the foot and drawing it in the direction of dorsal flexion. All the instruments may be said to consist of some form of boot,

to the sole of which is attached a leg-iron or irons having a joint corresponding to that of the ankle, and fixed to the leg above by a circlet and strap. In some the leg-iron or irons extend to the thigh, and are then provided with a second joint corresponding to the knee. In most the iron or irons are laterally disposed. When one iron is used, this is usually placed on the outer side of the leg, occasionally on the inner side, rarely behind the calf. When two are used, one is placed on each side of the leg. The boot may be shaped like an ordinary boot, or have the form shown in Fig. 147. The sole is usually of leather, having in some forms a sheet of steel placed between the layers to give it more resistance


FIG. 148.—STEEL SPRING USED BY AUTHORS FOR OVERCOMING EQUINUS.

and prevent it rolling up in front under the traction of the elastic force used to produce the dorsal flexion. The elastic force is applied either by a steel spring or by india-rubber. The spring may be variously arranged, as shown in Figs. 148, 149. The rubber may take the form of cords or rings, as shown in Figs. 147, 151. The action of the springs, and manner of attachment of the rubber cords or rings, will be understood by reference to the illustrations; no detailed description is necessary. The boot we usually employ is shown in Fig. 148. On the whole, we have

found the spring there represented the most serviceable and efficient. The rubber rings and cords are cheaper, but wear out more quickly than the spring we employ, and, having to be renewed frequently, cost more in the end. The leather straps, etc., attaching the cords or rings to the boot and leg-irons, are apt to stretch, and, having to be left for their adjustment to the mother or nurse, are liable to be inefficiently secured. The spring requires oiling occasionally, to prevent it becoming rusty and impeded in its action by the accumulation of dirt in the ring through which it slides.

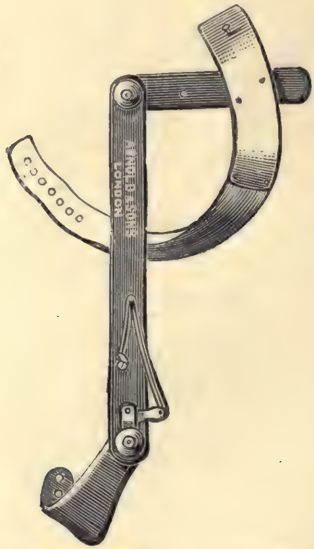



FIG. 149.—SPRING FOR OVERCOMING EQUINUS. (After Rédard.)

(2) *Apparatus for Continuing the Eversion as well as the Dorsal Flexion of the Foot.*—We personally seldom employ this. We consider it better where such seems required to take more radical measures to overcome the varus. The principle at the bottom of the apparatus for the further eversion of the foot as well as further dorsal flexion, as in that for promoting dorsal flexion alone, lies in the employment of elastic traction on the anterior part of the foot in the direction of eversion. Like the

apparatus for producing dorsal flexion, it may be said to consist of a boot and leg-irons with springs, or rubber cords or rings so attached as to draw the anterior part of the boot outwards as


FIG. 150.—SAYRE'S BOOT FOR CORRECTING EQUINUS AND VARUS BY RUBBER CORDS.

well as upwards. In perhaps its simplest form the rubber cord, which runs obliquely across the dorsum of the foot, is attached


FIG. 151.—BOOT USED BY AUTHORS FOR OVERCOMING EQUINUS BY RUBBER CORD.

by straps at one end to the inner side of the toe of the boot, at the other end to the outer side of the calf-circlet. In some

forms the sole of the boot is divided, so that the anterior portion can be everted on the posterior (Fig. 150). In other forms the leg-iron is so attached to the boot that when it is secured to the calf it has a tendency to depress the inner, and raise the outer,

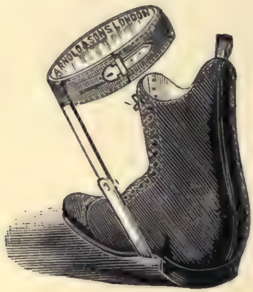


FIG. 152.—STILLMAN'S BOOT FOR CORRECTING THE TENDENCY FOR THE FOOT TO ROLL INWARDS AFTER THE CURE OF CLUB-FOOT. (After Hoffa.)

border of the foot, after the manner of the vertical spring in the Scarpa's shoe (Fig. 152).

*Stillman's Boot.*—Stillman, for overcoming the tendency for

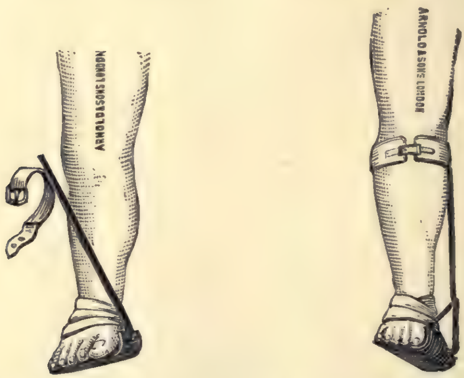


FIG. 153.—TAYLOR'S APPLIANCE FOR WEARING INSIDE THE BOOT.

the foot to roll inwards, employs the boot shown in the accompanying drawing. When the leg-iron, which for varus is placed on the inner side of the leg, is fixed by the calf-circlet, the foot is pushed over, and its tendency to roll inwards corrected (Fig. 152).

*Taylor's Appliance* is thus described by Bradford and Lovett. It 'consists of a flat steel sole-plate, which follows the outline of the lower surface of the foot, reaching forwards to the balls of the toes. At right angles to this rises an inner border from which a shaft extends up the leg at right angles to the sole-plate, the apparatus being jointed at the ankle. The foot is retained in the sole-plate by straps of webbing buckling over it. The sole-plate is applied to the deformed foot, and the upright as it is brought into position acts as a lever, as shown in Fig. 153, forcing the foot into place. The shoe is light, and can be worn inside a walking-boot without interfering with locomotion.'

**Physiological After-treatment.**—During the whole period of the treatment, and especially at the end of the more active measures, physiological treatment, as it is termed, should be systematically carried out. This consists of passive movements of the foot, massage, friction, and galvanism where there is wasting of the muscles. Whenever the plaster of Paris or mechanical apparatus is removed, the foot should be worked in the direction of dorsal and plantar flexion, abduction and adduction, and the muscles massaged and galvanized if necessary. If plaster of Paris is employed, it should be removed at least once, better twice, a week for this purpose. After the more active period of treatment, passive movements and massage should be continued at regular intervals daily till the movements of the foot have been rendered as normal as possible. At night-time, to prevent a relapse, a night shoe should be worn, and during the day a boot with leg-irons reaching to the pelvis, to counteract the tendency of the foot and leg to turn inwards (see 'Mechanical After-treatment').

STATISTICS OF CONGENITAL TALIPES VARUS.—During ten years (1882-1893) 153 cases* of congenital talipes varus were treated in the Orthopædic Department of St. Bartholomew's Hospital. Of these 153 cases, 98 were males, 55 females. In 57 cases both feet were affected; in 96 one foot only. Four of the patients had genu retrorsum, 2 spina bifida, 1 club-knees. Club-foot was present in the father in 2 cases, in the mother in 1, in a brother

* These numbers do not include the cases admitted at once as in-patients to the hospital under the care of Mr. Walsham, or under the care of the other Surgeons either as in or out patients.

in 1, in a sister in 1, and in an uncle in 1. In 6 cases the opposite foot was in a condition of talipes calcaneus.

Thirty-nine cases were treated by plaster of Paris bandages and manipulation only, 101 by division of the tendo Achillis (in 13 cases this tendon had to be divided a second time). In 16 cases division of the tibialis anticus, and in 19 cases division of the tibialis posticus as well as the tibialis anticus, was practised previous to division of the tendo Achillis. In 8 moderately severe or relapsed cases syndesmotomy of the astrago-scaphoid capsule was performed.

There were 30 relapsed cases treated, 20 of them coming from other hospitals.

The more serious operations, such as Phelps' open incision, astragalectomy, etc., were, of course, only done on patients in the wards, and are not included in these statistics.

# CHAPTER V.

## ACQUIRED TALIPES VARUS.

ACQUIRED talipes varus is not common. When inversion of the foot occurs as an acquired deformity, it is nearly always combined with more or less plantar flexion, a condition described under acquired talipes equino-varus.

**Etiology.**—Simple acquired talipes varus, like acquired equino-varus, is almost invariably the result of infantile paralysis. Very rarely it may be due to spastic paraplegia and hysteria. There is a unique specimen in our museum, in which it was due to the contraction of the cicatrix of a burn on the inner side of the foot (Figs. 154, 155). The deformity may depend upon paralysis of the peronei alone, the foot then falling into the varus position, in which it may become fixed by the contraction of the tibials and shortening of the ligamentous structures on the inner side of the foot. Or it may depend upon extensive paralysis of the leg muscles, the tibialis anticus, and more rarely the tibialis posticus as well, alone escaping. Under the latter circumstances, the foot is held in the varus position by the unbalanced tibials, the tibialis anticus, which has some power over dorsal flexion as well as adduction, counteracting the tendency of the foot to fall into the equinus position. Pure varus, therefore, is met with under two conditions, very limited and very extensive paralysis, *i.e.*, paralysis localized to the peronei, and paralysis affecting all the muscles with the exception of the tibialis anticus or anticus and posticus. In the former condition, except some slight decrease in the size of the leg, there may be but little external evidence of the cause; in the latter, the marked wasting of the limb and other signs of infantile paralysis will render the cause at once apparent. The reason why pure varus is less common than

equino-varus is, therefore, readily explained. For in the slighter cases of infantile paralysis, the anterior muscles, as well as the peronei, are generally affected; hence the foot falls into the plantar-flexed as well as into the adducted position, and becomes fixed therein by the contraction of the unaffected calf muscles. Whilst on the other hand, in extensive paralysis it is more common for some portion of the calf muscles than for the tibials to escape, and hence the foot, which falls naturally into the equino-varus position, becomes fixed in the position of plantar flexion with some inversion by the contraction of the calf muscles.

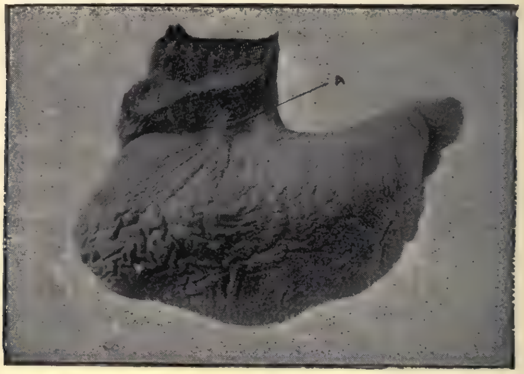



FIG. 154.—PHOTOGRAPH OF A SPECIMEN OF TALIPES VARUS CAUSED BY THE CONTRACTION OF THE CICATRIX OF A BURN ON THE INNER SIDE OF THE FOOT. (St. Bartholomew's Hospital Museum, No. 3226D.)

The centre of the contracting cicatrix is shown at A.

**Description.**—The foot presents similar appearances to those of the congenital variety, save that there is no elevation of the heel. The patient walks on the outer edge of the foot; the inner edge is raised, the toes point inwards, and the plantar arch is usually increased in depth. In the common form, that due to paralysis, the limb, when the paralysis is extensive, is wasted, and presents the peculiar character of infantile paralysis. It is cold, and usually bluish-red and congested; whilst sores may be found over the parts walked on, and over the malleoli and other situations rubbed by the boot. When, however, the paralysis is limited to the peronei, there

may be little beyond some slight wasting to indicate the cause. In the earlier stages in young children, there is not the rigidity that is present in congenital varus, and the shape of the foot can be restored on manipulation with the hand. In more advanced cases and in older children, the foot, in consequence of changes in the articular surfaces of the bones, and the adaptive shortening of the ligaments and tibial muscles, may become fixed in the deformed position. Mr. Adams calls attention to the absence in the paralytic form of the transverse and longitudinal furrows in the sole and of the irregularities on the dorsum, features which are well marked in congenital varus and serve for the diagnosis

FIG. 155.—PHOTOGRAPH OF A SPECIMEN OF TALIPES VARUS CAUSED BY CONTRACTION OF THE CICATRIX OF A BURN ON THE INNER SIDE OF THE FOOT. (St. Bartholomew's Hospital Museum, No. 3226D.)

A pad of thickened tissue (B) upon which the patient walked is seen on the outer edge of the foot.

in doubtful cases, as, for instance, in adult congenital varus, where a history cannot be obtained of the deformity being present at birth, and where the wasting of the limb in consequence of prolonged disuse of the muscles causes it to simulate the paralytic form.

In some cases the wasting of the limb is extreme, only the tibialis anticus, and perhaps the tibialis posticus also, responding to electrical stimulation. In other cases, however, the wasting is much less marked, and the other evidences of infantile paralysis,

such as the congested and bluish appearance of the skin, may be almost or completely absent. In such, as stated under etiology, the deformity depends upon the peronei being alone or chiefly affected by the paralysis.

The *spastic form* sometimes met with in the so-called spastic paraplegia of children is very rare, equino-varus being much more common in this condition. The foot, which is held in the position of varus by the rigid muscles, gradually yields under the surgeon's hands on attempting to correct the deformity. The

FIG. 156.—PHOTOGRAPH OF HYSTERICAL VARUS IN A GIRL AGED THIRTEEN YEARS, ATTENDING THE ORTHOPÆDIC DEPARTMENT OF ST. BARTHOLOMEW'S HOSPITAL.

presence of spasticity of the muscles of the knee and hip, and especially of the adductors, with probably some similar spastic condition of the muscles of one or both upper limbs, together with a weakened mental state of the patient, will help in the diagnosis.

In *the hysterical form*, of which we have seen several examples in the Orthopædic Department, there is no wasting of the limb, and the foot can be brought into position as the adductor muscles are tired out by the surgeon making prolonged efforts in the direction of restoration of the foot. Under an anæsthetic, moreover,

the foot falls into the natural position, and there are commonly other signs of hysteria present (Figs. 156, 157).

**Morbid Anatomy.**—*The Bones.*—At first there may be no alteration in the shape of the bones, but later, when the foot has been walked on in the deformed position, similar though less marked changes occur to those described under congenital varus. Indeed, as Mr. Adams points out, some of the descriptions of the morbid anatomy of congenital varus have really been taken from specimens of adult paralytic varus, or equino-varus. Perhaps the most striking difference in the bones is the absence in the acquired variety of the inward and downward bend in the neck

FIG. 157.—PHOTOGRAPH OF THE FEET SHOWN IN THE PRECEDING FIGURE AFTER CURE BY MORAL PERSUASION.

of the astragalus, and of the inward twist, especially at its anterior end, in the longitudinal axis of the os calcis, the features so distinctive of the congenital form.

*The Ligaments.*—At first there may be but little alteration in the ligaments, but later those on the inner side of the foot undergo adaptive shortening.

*The Muscles.*—In the paralytic cases, the affected muscles are found in a state of more or less complete fatty degeneration. In the most severe grades all the muscles of the leg and foot, with the exception of the tibialis anticus, and sometimes the tibialis anticus

and posticus, may be found affected. In other cases* only the peronei appear to have suffered. In the spastic and hysterical cases there will be no fatty degeneration, but the actual condition of the muscles in the spastic cases is hardly understood.

**Treatment**.—In *paralytic cases* where there is no rigidity, and the foot can be readily placed in the natural position, a boot with an inside leg-iron and a varus T-strap should be worn to hold the foot in place. If there is any shortening of the limb, the sole of the boot should be raised to compensate for this. When the muscles of the thigh acting on the knee-joint are also affected with the paralysis, and the knee-joint is loose in consequence of relaxation of the ligaments, the iron should be carried up on the outside of the thigh to a pelvic girdle, the joint at the knee being provided with a ring catch (Fig. 192), or other such contrivance for fixing the limb in the extended position. In extreme paralytic cases an inside iron as well as an outside iron will usually be found necessary with a double T-strap, since otherwise, when the single varus strap is tightened, the foot, in consequence of the extensiveness of the paralysis, will be simply drawn into the valgus position. With a double iron and double T-strap, the foot can be held with a little adjustment in a position midway between the irons. Where the tibials are rigid, they may be subcutaneously divided, and the foot rectified by plaster of Paris, before the walking instrument described above is applied. Except, perhaps, in the most severe cases, some success may be expected from the long-continued perseverance in electricity and massage. In the slighter cases of paralysis, in which only the peronei are involved, electricity and massage are of the greatest use.

In *spastic cases*, a similar boot and iron to that described above may be worn. Tenotomy is generally held to be of little or no service. In recent years, however, the question of tenotomy has been re-opened, especially in America, and it is there strongly advocated by some surgeons. We have tried it in a few instances, but our experience has hardly been sufficient, since these cases are rare, to pronounce either for or against it.

* This statement is made from clinical and electrical experience—not from actual dissection.

*Hysterical cases* should be treated on general principles. Confining the foot in the rectified position in plaster of Paris for a few weeks, and the occasional application of the battery combined with moral persuasion, will generally be found successful (Fig. 157).

## CHAPTER VI.

### TALIPES EQUINUS.

**Synonyms.**—Horse-heel ; Pes equinus ; Pied bot équin ; Pferdefuss ; Spitzfuss ; Piede equino.

**Definition.**—Talipes equinus, so named from the fancied resemblance of the deformed foot to that of the horse, is a condition in which the foot is maintained in a position of plantar flexion or cannot be dorsiflexed beyond a right angle with the axis of the leg.

The definition of equinus usually given in text-books only refers to cases of medium severity; but the above will be found to include all cases, from those of right-angled contraction to those of extreme equinus with retroverted foot.

**Descriptions and Signs.**—Talipes equinus is one of the simplest deformities of the foot. In the slightest grade, that known as right-angled contraction of the tendo Achillis, there may be no deformity whatever, the only fault being that the foot cannot be dorsiflexed beyond a right angle with the leg. In the more severe grades, the position of the foot is still only one in which the normal foot can be placed in plantar flexion, and even in extreme degrees of the deformity the position is nothing more than a greatly exaggerated condition of plantar flexion.

We propose in the first place to describe a case of medium severity. In such, the patient treads upon the balls of the toes, the heel is raised off the ground, and the dorsum of the foot is more prominent than natural. The tendo Achillis is very tense, and stands out conspicuously. It is the chief, and in many cases the only obstacle to the replacement of the foot in its normal position. The dorsal surface of the foot is continued in almost the same vertical plane as the anterior surface of the leg, but owing to the

astragalus being partially tilted out of its socket in a forward and downward direction its upper limit is marked by a groove; whilst below this the projecting astragalus forms a somewhat rounded uneven prominence. Immediately below the prominent astragalus, the dorsum descends more or less sharply (in the more severe cases with an inclination backwards) as far as the metatarso-phalangeal joints, and at this situation the plane of the phalanges forms a right angle with the line of the metatarsal bones. The patient appears, therefore, to walk on the toes, though in fact the weight is borne on the heads of the metatarsal bones. The heel is raised so that the long axis of the os calcis is

FIG. 158.—TALIPES EQUINUS WITH CAVUS FOLLOWING INFANTILE PARALYSIS. (From a photograph taken in the Orthopædic Department of St. Bartholomew's Hospital by Mr. Clindening.)

The long axis of the os calcis is almost horizontal.

inclined downwards, forwards, and inwards instead of forwards and slightly upwards as in the normal foot; but the degree of inclination varies according to the amount of contraction of the tendo Achillis. The elevation of the heel often appears greater than it really is; indeed, as pointed out by Mr. Adams, the equinus in a case of moderate severity the result of infantile paralysis is not so much due to an elevation of the heel as to a depression of the anterior part of the foot, and, contrary to what might have been expected, the os calcis has often a less vertical position than it has in congenital varus or equino-varus.

In a normal foot the long axis of the os calcis runs from behind almost directly forwards with an upward inclination; in medium cases of talipes equinus it points almost directly forwards, with generally a slight downward inclination which becomes more marked as the contraction of the calf muscles is increased, so that in a very severe case the long axis points directly downwards (Figs. 158, 174). The foot is slightly diminished in its long axis and the plantar arch deepened. When this latter change is marked, the foot is said to be in a condition of cavus, and some cavus is nearly always present in long-standing cases; but since

**Fig 159.—Talipes Equinus following Infantile Paralysis. (From a photograph taken in the Orthopædic Department of St. Bartholomew's Hospital.)**

**The large prominence on the dorsum of the foot is due to the extrusion of the astragalus from the ankle-joint. The metatarsal bones are in a line with the tibia. The long axis of the os calcis points forwards and slightly downwards.**

cavus also occurs in other deformities of the foot, and sometimes, apparently, as a primary condition independent of other deformities, it is described as a separate form of talipes (see Cavus). The cavus that occurs in equinus, and forms so marked a feature in long-standing cases of that deformity, is apparently due to several causes. In Chapter I., whilst discussing the action of the muscles of the leg, it was mentioned that the muscles that assist the tendo Achillis in raising the body on tip-toe (namely, the

plantar flexors, the tibialis posticus, the peronei, and the short muscles of the sole) also produce, by their contraction, a deepening of the plantar arch. Now since in equinus these muscles may be looked upon as in a state of permanent contraction, in that they have undergone shortening, in adaptation to the approximation of their attachments which has followed upon the plantar flexion of the foot, they may be regarded as one of the causes of deepening the arch. But a deepened arch is one in which its piers, namely the heads of the metatarsal bones and the posterior tuberosity of the os calcis, are approximated. Hence the plantar fascia and other soft tissues in the sole which stretch between these piers also undergo adaptive shortening, and thus further maintain the condition of cavus. In addition to muscular action, the cavus no doubt also depends on the vertical position of the foot, the weight of the body tending to force down the astragalus and os calcis towards the heads of the metatarsal bones. Further, in old-standing cases the alteration in the shape and direction of the articular surfaces of the bones renders the deepening of the arch permanent. It is probable that muscular action takes the chief share in the production of the cavus, seeing that marked cavus is often present in right-angled contraction of the tendo Achillis, where the weight of the body would have little power in producing the deformity.

In equinus there is no lateral deviation of the foot, either inwards or outwards, such deviation being regarded as equino-varus or equino-valgus respectively. Dr. Little,* however, holds that when there is merely a slight deviation inwards, the deformity should still be classed under simple equinus, as it is natural for the foot to have a slight inward inclination when plantar-flexed.

The patient, when walking, treads upon the heads of the metatarsal bones and bases of the first phalanges; in consequence of this, these bones are somewhat separated laterally, and the anterior part of the foot is broadened in the region of the metatarsal bones and phalanges.

Corns very frequently form on the ball of the toes, more especially beneath the heads of the first and fifth digits. These give rise to much pain in walking, as they are situated on the

* Little, *op. cit.*

only parts of the sole upon which the patient can tread, and therefore they soon become inflamed, and even suppurate, and render him incapable of walking at all on that limb. Pain in the instep is also frequently complained of, especially when the patient wears ill-fitting boots that give rise to undue pressure on the dorsum.

In paralytic cases, when the toes are bent backwards, corns are developed over their dorsal surfaces, and may inflame and suppurate, forming intractable ulcers; and when the foot itself is doubled under so that the patient walks on the dorsum, callosities and adventitious bursæ often give rise to much suffering. Should they become inflamed and suppurate, the ulceration that ensues may necessitate amputation of the foot.

Patients with equinus have difficulty in walking, for various reasons. In slight cases there is seldom any shortening, and therefore the limb with the equinus is in reality too long, and the toes are apt to catch the ground, so the patient has to swing the foot out or walk with the knee bent.

In more advanced cases of equinus, where the deformity has arisen as a result of ankylosis of the ankle, or of hemiplegia or other condition which does not give rise to shortening of the limb as a whole, there may be much inconvenience in walking, but the difficulty can still generally be fairly met by bending the knee in progression. When, however, marked paralysis is present with equinus, the limb is more or less useless for the purpose of progression, and the patient has to use a crutch on that side.

When both sides are affected with moderately severe equinus, progression is almost, and in extreme cases quite, impossible without the aid of crutches.

Some have expressed surprise that lateral curvature of the spine does not more often occur in this condition, but since the patient can nearly always rectify the inequality himself by bending the knee, there is no tendency to throw the whole weight of the body on one leg and so act adversely on the spine.

**Right-angled Contraction of the Tendo Achillis, or Rectangular Talipes.**—There are some cases of slight contraction of the tendo Achillis which must be discussed under the head of talipes equinus, though no deformity is apparent. The foot to all outward appearances is normal, and when the patient is standing

the heel touches the ground (Fig. 160). He is observed, however, to walk in a peculiar manner, and complains of pain or discomfort during progression. If the surgeon attempts to dorsiflex the foot while the leg is fully extended on the thigh, he will only be able to bring it to a right angle with the leg; that is to say, dorsiflexion is limited owing to slight contraction of the calf muscles. In a normal foot dorsiflexion in the adult can be carried to an angle of 80° (Weber); in the child to a much more acute angle; in babies the dorsum can be made to touch the anterior surface of the leg. It is necessary to take care that the leg is fully extended on the thigh, and that the knee is well pressed back, while dorsiflexion is being attempted; for if not slight cases of contraction

FIG. 160.—RIGHT-ANGLED CONTRACTION OF THE TENDO ACHILLIS, OR RECTANGULAR TALIPES, IN A YOUNG ADULT, WITH MUCH WASTING OF THE MUSCLES OF THE LEG AND FOOT ON THE RIGHT SIDE, FOLLOWING UPON AN ATTACK OF INFANTILE PARALYSIS IN INFANCY. (From a photograph by Mr. Griffiths of a patient attending the Orthopædic Department of St. Bartholomew's Hospital.)

of the tendo Achillis may be overlooked, since flexion of the leg relaxes the calf muscles. Although there is but little external evidence of this condition, the patient has a marked alteration in his gait, especially when both feet are affected. He limps, and there is no elasticity in his step. The hinder foot is brought forward without any spring, as when a person is walking on stilts. He experiences difficulty in walking up-hill, as the toes are then not sufficiently raised to prevent them catching against the ground. It is also said that there is difficulty in ascending

or descending stairs, but we have never satisfied ourselves that patients find any more inconvenience in going up and down stairs than in walking on level ground. The patient soon becomes tired owing to the continuous strain resulting from the anomalous condition of the muscles. If right-angled contraction of the tendo Achillis is not relieved, it may pass into a severer form of equinus, in consequence of the progressive unopposed contraction of the calf muscles.

In contradistinction to these cases of rectangular talipes, in many of which the condition is due to slight paralysis of the anterior muscles, which, however, have regained their tone, cases occur in which the anterior muscles remain permanently para-

FIG. 161.—CASE OF RIGHT-ANGLED CONTRACTION CURED BY EXERCISES AND MANIPULATION ONLY. (The photograph was taken three weeks after treatment had commenced.)

The right calf was smaller than the left. The right anterior muscles were slightly impaired.

lyzed. In such cases an extreme degree of talipes equinus may be the result. The foot is then plantar-flexed—it may be to an angle of 180° with the leg—and the patient walks on the dorsum of the foot. The weight of the body soon produces relaxation of the anterior ligaments, and the foot becomes still further doubled up, so that the patient treads on the dorsal aspect of the astragalus whilst the anterior portion of the sole looks upwards. Between these two conditions of rectangular talipes and extreme equinus there is every variation in degree.

The cases following infantile paralysis depend upon the extent and severity of the primary and permanent paralysis of the anterior muscle for the position they ultimately assume. The case described at the beginning of this section is, as we have mentioned, one of medium severity, and stands half-way between the cases of rectangular talipes and those of extreme equinus.

In equinus the phalanges may assume one of four conditions. Thus, (1) they may have the normal relation to the metatarsal bones (Fig. 162); (2) they may assume a clawed position, the first phalanx being strongly dorsal-flexed, the two distal phalanges plantar-flexed (Figs. 163, 164); or (3) they may be doubled under

FIG. 162.—TALIPES EQUINUS IN A YOUNG ADULT, FOLLOWING UPON AN ATTACK OF INFANTILE PARALYSIS IN EARLY CHILDHOOD. (From a photograph taken in the Orthopædic Department of St. Bartholomew's Hospital.)

Owing to the position in which the photograph has been taken, the equinus does not seem so pronounced as it really was. The toes are natural.

upon themselves, so that the dorsal surface of the toes looks downwards and touches the ground (Figs. 165, 166). In rarer cases (4) the great toe may project upwards whilst the tarso-metatarsal joint is depressed. This condition must not be confounded with the clawed toe due to contraction of the extensor proprius hallucis.

1. *The Phalanges may bear the Normal Relation to the Metatarsal Bones.*—Thus, in right-angled contraction of the tendo Achillis (the slightest degree of equinus), they are in line with the metatarsals, as in the foot in the ordinary position of standing.

Or in the case of equinus, described as typical of the deformity, they are at a right angle to the metatarsals, as in the normal foot when similarly placed in the position of equinus. This normal relationship of the phalanges occurs in cases of equinus in which

Fig. 163. — Photograph of a partially-dissected Specimen of Talipes Equinus with some Varus, Marked Cavus and Clawed Toes. Right Foot, Inner Side. (No. 3,514a, St. Bartholomew's Hospital Museum.)

The extensors and the interossei muscles are all of healthy tissue, and of good size. The long axis of the os calcis points forwards and slightly downwards from behind.

the anterior or dorsal muscles have never been more than slightly affected by the paralysis in the first instance, and have subse-

quently, to a great extent, recovered, though they still remain somewhat impaired, and do not to electrical tests show much activity.

2. *The Phalanges may assume a Clawed Condition.*—In this state the first phalanx is strongly dorsiflexed, the two distal phalanges are plantar-flexed (Figs. 163, 164). The clawing may be confined to the great toe, or it may affect all the toes. This condition of clawing may be explained as follows: Owing to the plantar flexion of the foot (equinus), the points of attachment of the

Fig. 164. — Photograph of a partially-dissected Specimen of Talipes Equinus with some Varus, Marked Cavus and Clawed Toes. Right Foot, Outer Side. (No. 3,514a, St. Bartholomew's Hospital Museum.)

The extensors and the interossei are well developed, and show no degenerative changes. The extensors are tightly stretched and shortened. The tendo Achillis is small, and there is much wasting of the gastrocnemius. The whole leg is small and wasted.

anterior muscles are abnormally separated. The anterior muscles themselves, having very nearly recovered their original strength, strive to overcome this abnormal separation; but their proximal attachment to the fibula being more or less a fixed point, whilst their distal attachment to the toes is to a great extent a movable one, in endeavouring to approximate their attachments

FIG. 165.—TALIPES EQUINUS IN AN ADULT FOLLOWING UPON A SEVERE ATTACK OF INFANTILE PARALYSIS IN INFANCY. (From a photograph taken in the Orthopædic Department, St. Bartholomew's Hospital, by Mr. Griffiths.)

The muscles of the right leg and foot are much wasted, and almost universally degenerated, there being some slight power left in the gastrocnemius and long flexor of the toes and extensor proprius hallucis.

FIG. 166.—PHOTOGRAPH OF THE SOLES OF THE SAME FEET AS IN FIG. 165, SHOWING HOW THE SMALLER TOES ARE DOUBLED UNDER OWING TO THE COMPLETE PARALYSIS OF THE EXTENSOR LONGUS DIGITORUM.

they draw the toes nearer to the fibula. Thus contraction of the anterior muscles causes dorsiflexion of the first phalanx ; but the plantar-flexor muscles at the same time, acting strongly and being attached to the two distal phalanges, hold the latter in a position of plantar flexion.

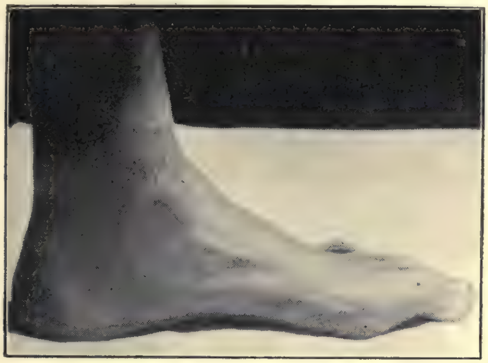


FIG. 167.—PHOTOGRAPH TAKEN A FORTNIGHT AFTER DIVISION OF THE TENDO ACHILLIS IN A CASE OF EQUINUS THAT HAD FOLLOWED UPON INFANTILE PARALYSIS IN INFANCY.

Immediate rectification was employed, and there was a separation of over two inches between the ends of the divided tendon. The patient, an adult, could walk quite comfortably three weeks after the operation. A good strong tendon resulted.

This explanation is in accordance with what occurs in a dissected foot, where, if the long flexor and extensor tendons are strongly pulled in the direction of their proximal attachment, the toes will assume the ' clawed condition.' It is further borne out by the fact that marked cases of clawed toes are generally met with in the slighter cases of equinus ; that is to say, in cases of rectangular talipes, where the anterior muscles have recovered almost entirely their normal strength and tone, and therefore are acting strongly. In moderately severe cases, clawing is not very frequently seen, except in the great toe ; and we may explain the frequency of clawing of this digit in the severe forms of equinus by the fact of its very powerful dorsal muscle. We see this when a child's foot is recovering from paralysis of the anterior muscles ; the great toe is then the first digit that assumes a position of

'clawed toe,' and is nearly always more markedly 'clawed' than any of the others. In the specimen from which Fig. 165 is taken, the great toe is the only digit in the 'clawed' condition. Here the extensor proprius hallucis is not affected to any great extent, while the extensor longus digitorum is completely paralyzed. This clawing of the toes is attributed by some authors to paralysis of the interossei, by others to spasmodic or spastic contraction of the anterior muscles.

With regard to the clawing being due to paralysis of the interossei, these muscles, even under favourable conditions, are difficult to put into action by galvanism or faradism. In talipes equinus they are placed at a great disadvantage on account of the

Fig. 168.—Talipes Cavus and Clawed Toes, with Right-angled Contraction of the Tendo Achillis, in an Adult, following upon Infantile Paralysis in Early Childhood. (From a photograph taken in the Orthopædic Department of St. Bartholomew's Hospital by Mr. Clindening.)

Contraction of the interossei of the third and fourth spaces was present to a slight extent.

contraction and adaptive shortening of their opponents, and are therefore much more difficult to stimulate by electricity. Hence, as might be expected, they are often reported to be paralyzed when it is probable that they are not thus affected. Moreover, contraction of the dorsal interossei is seen to be definitely present in a large number of cases of 'clawed toes' on stimulating the motor points, and this contraction will be found to increase in strength as the toes are made to assume their ordinary position after tenotomy of the anterior muscles and manipulation

of the toes. When their contraction is feeble, no reaction of degeneration can be demonstrated, and no evidence of the wasting so commonly seen and so well marked in the hand is to be found in the foot in these cases. Except, then, that their contraction is feeble, and in some cases is not obtained, no data are available to uphold the theory that the condition of clawing is due to paralysis of the interossei. Against the paralytic theory the following facts may be adduced:—First, that in some cases the interossei (dorsal) act well (Fig. 168). Secondly, that in many cases we at first only obtain slight contraction of some of the dorsal interossei, and then increased contraction upon correction of the deformity by tenotomy, which thus removes a large amount of resistance opposed to their action, showing clearly that the weakened contraction or absence of contraction is due to such opposing force. Thirdly, that the interossei are supplied by the same nerve (posterior tibial) as the posterior muscles, and therefore would be more likely to suffer with them than with the anterior muscles: it would be extremely improbable that the interossei alone of all the muscles supplied by the posterior tibial would be so often picked out in conjunction with the anterior muscles. Fourthly, that in the specimen of equinus with clawed toes from which Figs. 163 and 164 were taken, the interossei were found healthy. We would further point out the feebleness of contraction of the interossei in comparison with the long muscles of the foot, which makes it difficult to believe that, conversely, it is the normal action of the interossei that prevents the formation of 'clawed toes' in the undeformed foot.

3. *The Phalanges may be doubled under the Sole, so that their Dorsal Surfaces are walked upon.*—This condition is due to complete paralysis of the dorsal flexors of the toes, and is therefore a most unfavourable sign (Figs. 165, 166).

## Etiology of Talipes Equinus.

Talipes equinus may be due to various conditions. Thus, it may be (1) congenital, or the result of (2) infantile paralysis affecting the anterior muscles; (3) spastic paraplegia; or (4) pseudo-hypertrophic paralysis. It may depend upon (5) reflex irritation, as a long prepuce, irritation in the alimentary canal,

etc.; or it may be due (6) to hysteria, or (7) to long continuance of the foot in the plantar-flexed position consequent upon the weight of bedclothes during long confinement to bed. (8) It may be compensatory, the foot having been first held and then gradually having become fixed in the equinus position to compensate for inequality in the length of the legs. (9) It may be due to improper setting of a Pott's fracture or other fracture about the ankle, (10) or it may occur after disease in or around the ankle in consequence of the foot becoming ankylosed in the plantar-flexed position during healing. (11) It may be the result of

FIG. 169.—PHOTOGRAPH OF A CAST OF TALIPES EQUINUS FROM COMPLETE PARALYSIS OF ALL THE MUSCLES, ANTERIOR AND POSTERIOR. (St. Bartholomew's Hospital Museum.)

The right leg was much shorter than the left, and was not used in progression at all.

contraction of cicatrices following burns, ulcers and wounds in the region of the calf, or (12) of destruction of the anterior tendons by ulcers or sloughing, or the division of the tendons in wounds.

These causes will be enlarged upon in dealing with the varieties of talipes equinus. The question of the causation of the congenital variety is discussed under the cause of congenital varus, the most common form of congenital club-foot.

## Pathological Anatomy of Talipes Equinus.

Broadly put, the chief pathological changes in talipes equinus consist more in an alteration in the relation of the bones to each other than in any marked alteration in the shape of the bones themselves. The tuberosity of the os calcis is more or less


FIG. 170.—PHOTOGRAPH OF THE SKELETON OF A FOOT IN A CONDITION OF TALIPES EQUINUS FOLLOWING INFANTILE PARALYSIS. (From a specimen in the possession of Mr. Walsham, and now added to St. Bartholomew's Hospital Museum.)

The tibial articular surface is only in contact with the posterior portion of the astragalus, and articulates with the os calcis. The new articular surface (A) is enclosed by a ring of white paint. The metatarsal bones are in almost a straight line with the tibia. The long axis of the os calcis runs from behind, forwards, and slightly downwards. The phalanges articulate with new articular surfaces upon the dorsal portion of the heads of the metatarsal bones.

elevated, the astragalus in consequence tilted to a greater or less extent out of the socket formed for it by the bones of the leg, whilst the tarsal bones at the transverse tarsal joint are bent

upon themselves, the bones in front of that joint being depressed in the direction of plantar flexion. This bending of the bones upon themselves is looked upon by Mr. Adams as playing a more important part in the production of the deformity than the elevation of the os calcis and consequent tilting of the astragalus out of the ankle-joint.*

The ligaments of the anterior aspect of the foot are stretched and elongated; the ligaments on the plantar and posterior aspec are shortened and contracted; the anterior muscles are to a greater or less extent atrophied and wasted. In paralytic cases they may be partially or completely in a state of fatty degeneration. The posterior muscles of the leg and the shorter muscles of the sole of the foot, with the plantar fascia, are proportionately contracted and shortened, and are the chief agents in holding the bones in the deformed position. Thus, in slight cases, and to a less extent in severe cases, the position of the foot is one that can be assumed by the normal movement of plantar flexion, the foot, however, except in slight cases, being further bent upon itself by the depression of the bones which lie in front of the transverse tarsal joint. In acquired cases, excepting those due to paralysis and of long standing, the muscles are, as a rule, but little altered, and although the anterior ligaments may be stretched, and the posterior ligaments shortened, the foot can be, it may be said almost always, restored to its natural shape and usefulness.

The alterations in the bones, ligaments and muscles are next considered in detail.

**The Bones.**—It has already been stated that the alteration in the bones consists more in changes of their relation the one to the other than in any pronounced alteration in form, such as is found in congenital varus.

The following description is based, for the most part, on a specimen of marked equinus, probably of paralytic origin, in our possession, and now added to the museum of St. Bartholomew's Hospital (Fig. 170). The displacement and alteration in the bones agree in all essential particulars with similar specimens preserved or described elsewhere. We have had no opportunity of examining a specimen of equinus of undoubted congenital origin either in the adult or in the infant, but it would not appear

* Adams, p. 83, 1866 edit.

that there are any essential changes in the bones beyond those observed in other varieties of equinus. The bones in our specimen are somewhat atrophied, and the foot is smaller than its fellow, the atrophy, however, not being so marked as in the specimen of talipes calcaneus illustrated in Fig. 226. In some specimens, very little atrophy has occurred. The tibia articulates only with the posterior portion of the astragalus, the anterior part of the trochlea of the astragalus being exposed. The posterior edge of the articular surface of the tibia not only articulates with the astragalus, but is in contact with the upper surface of the os calcis, and forms with it a new articulation (Figs. 171, 172). In the photograph (Fig. 170) the tibia and os calcis have been slightly separated the better to show the posterior half of this new oval facet on the os calcis. The posterior part of the external malleolus of the fibula also articulates with the os calcis (Fig. 171).

**The Astragalus.**—The astragalus occupies a nearly vertical position; its long axis is directed downwards and but very slightly forwards, and if continued onwards would strike the first interphalangeal articulation of the great toe.

*The Trochlea, or Superior Articular Surface*, is much altered; its anterior half is exposed and completely denuded of cartilage in front, and partially denuded further back (Fig. 171). The posterior part of the trochlear articular surface is prolonged backwards beyond the posterior edge of the astragalus, over the normal non-articular surface of the astragalus, on to the os calcis, where it forms a well-marked and somewhat oval articular surface posterior to and continuous with the posterior superior astragaloid facet on the os calcis (Figs. 171, 172). This new articular surface for the tibia is not well defined like that on an ordinary astragalus, on account of the uneven nature of the posterior portion of the bone, and also on account of the attached ligaments. The anterior limit of the new articular surface for the tibia commences about the mid-transverse line of the original trochlea. It expands as it passes backwards, reaching its widest part about the situation of the original posterior limit, which was the narrowest portion of the original trochlea. The rest of the new articular surface for the tibia is, as just stated, somewhat indistinctly marked out. That portion of it, however, on the os

calcis is smooth and well defined, and articulates with the posterior edge of the tibia, which is normally non-articular.

The upper surface of the trochlea is increased laterally at the expense of the articular facet for the internal malleolus.

*The External Malleolar Articular Surface* is displaced backwards beyond the bone on to the os calcis, and forms there a small oval articular facet external to and continuous with the postero-external angle of the posterior facet for the astragalus (Figs. 171, 172). The anterior portion of the original articular surface is exposed, and denuded of cartilage. The new articular surface for the external malleolus is divided into two parts—a larger anterior and a smaller posterior portion—by an interval filled up by ligamentous tissue in the fresh specimen. The anterior and larger part articulates with the anterior and upper part of the external malleolus and with a sesamoid bone developed in the external lateral ligament below the anterior edge of the malleolus. The posterior portion of the facet which is situated on the os calcis articulates with the malleolus posterior to the insertion of the posterior fasciculus of the external lateral ligament, and with the posterior surface of the ligament itself.

*The Internal Malleolar Articular Surface* has also undergone much displacement backwards, its anterior limit corresponding to the mid-transverse line of the original facet on the malleolar surface, the anterior portion of the original facet being represented by a hollow which is covered by ligaments. The new facet is not well defined, owing to the uneven character of the posterior portion of the astragalus above referred to.

*The Inferior Articular Surfaces* are not materially altered, and require no special description. With the bone *in situ*, that is, in the equinus position, they look directly, or almost directly, backwards instead of downwards, as in the normal position of the bone.

*The Convex Articular Surface on the Head* is somewhat smaller than normal, in consequence of the downward displacement of the scaphoid having left the upper portion of the head exposed, and the exposed part having become to a greater or less extent denuded of cartilage. In the severe degree illustrated in our specimen, the head itself is directed almost vertically downwards (Fig. 170).

*The Posterior Surface of the Astragalus* is encroached upon by the superior articular surface. The groove for the flexor longus hallucis has completely, or almost completely, disappeared, its place being taken by the backwardly prolonged trochlear surface.

Viewing the astragalus when resting on its articular surfaces for the os calcis, its antero-posterior curve appears somewhat altered. Thus the posterior portion of the bone describes a curve with its convexity backwards; whilst the anterior portion or neck is placed horizontally without any inward deflection. When the bone is held in the equinus position, the normal antero-posterior axis is directed almost vertically downwards, the neck thus forming with the articular surface for the tibia an angle of about 80°. The neck forms nearly half the length of the bone, being increased through the depression of the scaphoid, exposing a portion of the articular surface of the head to the extent of three-eighths of an inch on the outer side, and a quarter of an inch on the inner. The whole bone is compressed in its antero-posterior axis.

**The Os Calcis.**—The tuberosity of the os calcis is raised, and the long axis of the bone, in place of being directed forwards and slightly upwards, runs forwards and downwards; only slightly downwards in the less severe grades of the deformity, considerably downwards in the more severe. But the amount of elevation of the tuberosity has been the subject of some dispute. In Fig. 174 the long axis is almost parallel to the bones of the leg. In Fig. 162 the tuberosity is but little raised. The contradictory statements as regards the elevation of the posterior part of the os calcis appear to depend upon descriptions having been taken from different degrees of the deformity, the truth being that every degree of elevation may be met with, from that in which there is only a slight departure from the normal, to an extreme degree in which the bone may be parallel to the axis of the leg. This is what we might expect if we consider that the degree of paralytic equinus depends upon the amount of destruction of tissue in the anterior muscles, and the more or less healthy condition of the posterior muscles. Thus, where the anterior muscles are but slightly affected the elevation of the posterior part of the os calcis will be slight; where they are deeply affected, and the posterior muscles are comparatively free from degeneration, the elevation will be extreme. Not only is the tuberosity

elevated, but it is drawn towards the fibular side of the leg, so that the posterior part of the os calcis lies behind the fibula and tibio-fibular articulation.

*The Superior Surface.*—The posterior articular facet, which is smaller than normal, is continuous behind with two new articular facets: an inner one for articulation with the outer portion of the posterior part of the trochlear surface of the tibia, an outer and smaller one for articulation with the back of the external malleolus (Figs. 171, 172). These facets are separated from the posterior


FIG. 171.—THE OS CALCIS AND ASTRAGALUS FROM AN OLD-STANDING CASE OF TALIPES EQUINUS DUE TO INFANTILE PARALYSIS. Seen from above.

The continuous lines enclose the new articular surface for the tibia and fibula. The dotted line encloses the anterior portion of the original trochlear surface, the cartilage of which is destroyed. 1. The articular facet for the external malleolus in front of the posterior fasciculus of the external lateral ligament. 2. The articular facet for the exterior malleolus posterior to this ligament. 3. The new facet for the tibia on the os calcis.

articular astragaloid facet by a distinct ridge, and when the bone is held in a normal position, with the astragaloid articular facets looking almost directly upwards, these facets look almost directly backwards. With the bone in position of equinus the new facets

consequently look upwards, or upwards and slightly backwards, and the normal astragaloid facets directly forwards, or forwards and slightly upwards. Whether these facets are newly formed on the new articular surface of the bone behind the normal posterior astragaloid facet in consequence of the tibia and fibula coming in contact with this portion of the bone as the tuberosity is raised, or whether they are merely a part of the normal facet which has been left exposed by the astragalus sliding forwards

FIG. 172.—THE SAME PARTS AS SHOWN IN THE PREVIOUS PHOTOGRAPH FROM A SLIGHTLY DIFFERENT ASPECT.

The new articular facet on the os calcis for articulation with the tibia is well seen. Part of the original trochlear surface on the astragalus, now rough and uneven, lies in front of the anterior white line.

(downwards in the equinus position), it is difficult to say. If the latter is the correct explanation, then it must be assumed that the posterior part of this normal facet has had its direction changed in consequence of pressure against the tibia. Several facts in our specimen favour this view. Thus, the distance from

the posterior part of this new facet to the back of the tuberosity corresponds to the distance from the posterior part of the normal astragaloid facet to the back of the tuberosity. Further, the normal facet at its posterior part has a distinct backward inclination; and lastly, when the astragalus and os calcis are articulated, it appears that the astragalus occupies a more anterior position on the os calcis than when the two normal bones are thus placed in apposition. The view, therefore, we are inclined to adopt is that the weight of the body transmitted to the astragalus has caused that bone to slide at first forwards and downwards, and, as the elevation of the heel has increased, directly downwards on the os calcis, which latter bone takes a position more and more posterior and parallel to the astragalus instead of one, as in the normal foot, directly beneath it. If this is correct, the exposed portion of the posterior articular facet for the astragalus, as it comes into contact with the tibia, is gradually altered in its direction as it receives more and more of the weight of the body transmitted to it through the tibia. The same explanation holds good, we think, for the external of the two so-called new articular facets, namely, that for the fibula.

*The Anterior Facet on the Sustentaculum Tali* looks forwards, or in slight cases forwards and upwards, instead of almost directly upwards; the groove for the flexor longus hallucis on its under surface is well marked. Its posterior margin almost corresponds to the posterior margin of the posterior astragaloid facet, instead of being half an inch or more in front of it, as in the normal bone. Behind the facets, the upper non-articular surface of the bone is much more concave than normal, giving this portion of the bone the appearance of having been bent upwards by the pull of the tendo Achillis.

*The External Surface* is rugged and uneven; the peroneal tubercle is well marked, and corresponds to the posterior margin of the posterior articular astragaloid facet instead of being some way in front of it.

*The Internal Surface and Inferior Surface* present nothing remarkable.

*The Anterior or Cuboidal Surface.*—The somewhat quadrilateral facet seen on this portion of the normal os calcis is reduced in our

specimen of talipes equinus to a narrow oval facet. This is situated on the lower part of the cuboidal surface; the upper part of this surface is denuded of cartilage for half an inch, and is exposed in consequence of the cuboid having fallen away from the os calcis in a downward and forward direction. When the bones are *in situ*, a wedge-shaped interval, with the base upwards, exists between the two bones; the wedge-shaped space measures at its base a quarter of an inch.

*The Posterior Surface of the Os Calcis* is altered in conformation as well as direction. Instead of looking backwards and slightly downwards, it looks backwards and more or less upwards. The tendo Achillis is attached almost to the upper end of the prominence, the bursa beneath it being likewise displaced upwards, the smooth surface indicating its situation lying partly on the superior surface of the bone. Looked at laterally, the whole of the posterior part appears to have been bent upwards to a greater extent than the rest of the bone, deepening the concavity on its upper surface. This change would appear to depend upon the constant traction of the tendo Achillis.

**The Scaphoid** is displaced downwards on the head of the astragalus, leaving the upper part of the convex head of that bone exposed. It appears also to have been drawn somewhat inwards, exposing in like manner the outer part of the astragaloid head. In shape it appears to have undergone little or no alteration; the diameter of the plantar surface from before backwards is, however, about half that of the dorsal. In the normal bone the proportion of these diameters is as 4 to 5.

**The Cuboid**, in consequence of its downward displacement, has its posterior articular facet exposed in its upper half, and there denuded more or less of cartilage. Thus this facet is reduced to an oval facet placed almost tranversely across the lower part of the posterior aspect of the bone. A wedge-shaped interval, with the base upwards, as stated in the description of the os calcis, exists between the upper portions of what were formerly the articular surfaces of these bones. The plantar surface is diminished in its antero-posterior diameter. The dorsal surface is, perhaps, increased, but only to a very slight extent. This alteration is such as might be expected to result from the increased pressure on the plantar and diminished pressure on the dorsal surface

consequent upon the bending of the foot upon itself at the transverse tarsal joint.

**The Cuneiform Bones** present little alteration save that their antero-posterior axes are slightly increased on the dorsal and diminished on the plantar aspects.

**The Metatarsal Bones.**—On the dorsal surface of the heads of the metatarsal bones, especially when the equinus is combined with the condition of the phalanges known as clawed toes, well-marked new articular surfaces for the dorsally displaced articular surfaces

FIG. 173.—PHOTOGRAPH OF A FOOT THE SUBJECT OF TALIPES EQUINUS. (St. Bartholomew's Hospital Museum.)

The new articular facets on the heads of the metatarsal bones are well seen. The equinus was the result of infantile paralysis.

of the bases of the first phalanges are formed. These are well shown in Fig. 173. In position the metatarsal bones assume an almost vertical direction. In very severe cases they may be carried somewhat backwards, so that their dorsal surfaces look forwards. They are also more or less separated from each other laterally at their distal ends. In consequence of this the foot is increased in

breadth at the spot where the weight is transmitted to the ground. In still more severe cases they may be bent completely backwards, so that their dorsal surfaces look downwards, the long axis of the bones being at right angles to the bones of the leg. This condition is only met with in paralytic cases, the weight of the body in such being transmitted to the ground through the

FIG. 174.—PHOTOGRAPH OF A SPECIMEN OF TALIPES EQUINUS.

There is complete fatty degeneration of all the muscles of the leg and foot. The right leg was much shorter than the left, and was not used in progression. The foot dropped into the equinus position from its own weight, and there became fixed.

head of the astragalus, the cuboid and the other tarsal bones in front of the transverse tarsal joint.

**The Ligaments.**—The plantar ligaments, especially the plantar fascia, the calcaneo-cuboid, and calcaneo-scaphoid, are contracted and shortened. The posterior ligament of the ankle-joint, the

FIG. 175.—PHOTOGRAPH OF THE FOOT AND PART OF THE LEG OF A GIRL AGED SIXTEEN, THE SUBJECT OF PARALYTIC EQUINUS WITH VARUS. (No. 3,515, St. Bartholomew's Hospital Museum ; Lawrence Ward Book, vol. ii., p. 402.)

The limb had not been used in walking for seven years, but up to nine years of age the girl walked on the dorsum of the foot. The paralysis occurred at the age of four. The gastrocnemius and soleus are said to have been fatty, but there is a well-formed tendo Achillis. The extensor longus digitorum is very small and fatty, and the tendons are thin and attenuated. The extensor proprius hallucis is in good condition, as is also the tibialis anticus. The posterior muscles, especially the flexor longus digitorum, are in good condition. Only the tendon of the peroneus longus is present, and it is very small—much smaller than that of the peroneus brevis, which is well represented. The tibialis posticus is said to have been fatty, but not a particle of the muscle or tendon is left in the specimen. This specimen, which is used here to illustrate the condition of the muscles in equinus, is referred to again under equino-varus, to which variety of talipes it perhaps more properly belongs.

posterior fasciculus of the external lateral ligament, and the posterior portion of the deltoid ligament, are also structurally shortened. The anterior ligaments between the astragalus and scaphoid, and the os calcis and cuboid, and the anterior ligament of the ankle-joint, are stretched and lengthened. The anterior portion of the deltoid and the anterior and middle fasciculi of the external lateral ligament are also lengthened. In long-standing and severe cases the contraction of these ligaments resists the restoration of the foot to the normal position. But where the bones are also altered in configuration, as in the specimen several times referred to, these changes in the articular surfaces have also to be taken into account.

**The Muscles.**—The condition of the muscles has been minutely studied by Messrs. Adams and Quekett, and has been found to present every deviation from the standard of health to complete fatty and fibrous degeneration. The muscles differ according to the cause of the equinus; in cases the result of position there may be but little change, except when the position of equinus has been long maintained, when the alterations characteristic of long want of use, such as wasting and atrophy, with some fatty infiltration, may be found. In the so-called spastic cases a fibroid degeneration has been observed. In paralytic cases every degree of wasting of some muscle or muscles, to complete fatty degeneration, may be present (Fig. 174). In the case from which Fig. 175 was taken—namely, that of a girl aged sixteen, in which, in consequence of infantile paralysis, the foot and leg had not been used for seven years—the gastrocnemius, soleus and tibialis posticus were found to have undergone complete fatty degeneration, though there is a well-marked tendo Achillis. The remaining deep posterior muscles have undergone but little change, the flexor longus hallucis appearing especially well developed. The extensor communis digitorum is small and fatty, and its tendons are thin and attenuated. The extensor longus hallucis and tibialis anticus are fairly normal. The peroneus longus was fatty, but only the tendon is left in the specimen, and this is very small—much smaller than that of the brevis, the belly of which was also fatty.

### Varieties of Talipes Equinus.

As we have already seen under the head of Etiology, talipes equinus may be the result of many different conditions, and almost as many varieties may be described as there are causes. We shall give a short account of the following: (1) Congenital; (2) paralytic; (3) spastic; (4) pseudo-hypertrophic; (5) reflex; (6) hysterical; (7) compensatory; (8) adaptive; (9) following fracture; (10) following disease of the ankle-joint; (11) following contraction of cicatrices; (12) following destruction of the anterior tendons and muscles.

(1) *Congenital Talipes Equinus.*—Congenital talipes equinus is very rare—so rare, indeed, that its occurrence has been denied by some writers. Adams, Little, and Hoffa, however, admit its existence, and Mr. Walsham has met with two cases whilst in charge of the Orthopædic Department at St. Bartholomew's Hospital. Messrs. Little and Adams have both seen three cases of pure congenital equinus, and Mr. Adams further says he has seen several cases of varus (equino-varus) in which the varus was so slightly marked that they might almost have been classed under equinus. In one case, of which casts of the feet are preserved in the museum of St. Bartholomew's Hospital, both feet were affected to an equal degree. The foot was in an extreme degree of plantar flexion, the heel was elevated and ill-developed, the tuberosity of the os calcis appeared small, the tendo Achillis was tense but not very prominent, and the whole foot was inclined slightly inwards. The inward inclination of the foot, however, appeared to be not more than what occurs in the normal foot in extreme plantar flexion—an inward inclination, due, we believe, as explained in our chapter on the movements of the foot, to the shape of the trochlear surface of the astragalus. There did not seem to be any inversion at the transverse tarsal and sub-astragaloid joints, such as occurs in varus (equino-varus). Indeed, a glance at the deformity was at once sufficient to distinguish it from one of very slight varus (equino-varus). There was a complete absence of the rounded outer margin of the foot, of inversion of the sole, and of adduction of the fore part of the foot, so characteristic of varus, even in the slightest degrees.

In the few cases of untreated congenital equinus in adults that Dr. Little has seen, the equinus has remained as pure equinus throughout, the patients still walking on the heads of the metatarsal bones, and especially on those of the great and little toes.

The sole in our patients was slightly concave, and the plantar fascia somewhat tense; the toes pointed downwards with a slight inclination backwards, as in cases of equinus with paralysis of the anterior muscles. The foot was not broadened at the situation of the heads of the metatarsal bones, as it so often is in cases of equinus in which the deformed foot has been used in progression. The muscles of the leg were well developed. We know of no dissection of the foot in congenital equinus, but from the appearances of the foot in our cases, we should imagine that the condition of the parts is similar to that which occurs in the non-congenital forms. In our cases the tuberosity of the os calcis was small, and from the drawing of congenital equinus given by Dr. Little in his book (p. 2), we should imagine it was also small in his patient. In his case, as in ours, the heel slopes forwards and downwards somewhat sharply and there is an absence of that graceful rounding off of the lower portion to be observed in the normal heel—a condition suggestive of a deficiency of the os calcis in this situation, and recalling the type commonly found of the defective heel and os calcis in congenital varus. The astragalus was extruded from its socket in a forward, downward and inward direction, and after division of the tendo Achillis could not be completely replaced. This might depend to some extent on the contraction of the posterior ligament, but over and above this it was felt that the anterior part of the trochlear surface locked against the tibia and malleoli, and that it was bone coming into contact with bone that prevented the replacement. We could not, of course, be certain that there was any downward deflection of the astragaloid neck; but the behaviour of the foot in forcible attempts at reduction leads us to believe that there was.

The etiology of congenital equinus opens up the whole question of the etiology of congenital deformities, for an account of which we must refer to the section on the etiology of congenital varus, the most common variety of congenital club-foot (p. 68). We may merely remark here that one of Dr. Little's cases was the

fifth example of congenital equinus in living members of the same family (father, two paternal uncles and one aunt).

(2) *Paralytic Talipes Equinus.*—Infantile paralysis is by far the most common cause of talipes equinus. In this affection the anterior muscles or dorsal flexors are more often involved than the posterior or plantar flexors. Therefore talipes equinus is more frequently met with than talipes calcaneus. In the orthopædic department of St. Bartholomew's Hospital during ten years there were 316 cases of paralytic equinus, and only 33 cases of paralytic calcaneus.

The reason for the foot taking the equinus position in infantile paralysis is variously believed to depend (1) on the contraction of the unopposed plantar-flexor muscles, and (2) on the foot, in consequence of the paralysis of the anterior muscles, falling into the position of plantar flexion or equinus through its own weight.

1. According to the first theory, when the anterior muscles are paralyzed, the posterior set, or plantar flexors, no longer opposed by their anterior antagonists, fall into a state of permanent or spastic contraction, and gradually draw the foot into the equinus position. Subsequently the foot becomes fixed in the deformed position by the contraction and shortening of the ligaments; whilst in old-standing cases the contracted muscles may undergo fibroid changes, and the bones various alterations.

2. The upholders of the second theory regard the deformity as purely the result of mechanical conditions acting on the foot deprived of the support it normally receives from the anterior muscles. During rest on the back, and when sitting with the leg hanging down unsupported, the foot normally falls into the plantar-flexed position, with slight inversion. As the result of the paralysis of the anterior muscles, it is held that the foot assumes this natural position, and that the contraction of the posterior muscles is merely the result of passive shortening consequent upon their attachments being approximated, and is not the result of any active contraction following the loss of their normal opponents.

When the paralysis of the anterior muscles is transitory and limited to only a few muscles, or only to some of their fibres, the

resulting equinus will be but slight; when the paralysis is widespread and severe, the equinus will be extreme.

In the slighter cases of paralysis the deformity is to some extent maintained by the anterior muscles being put out of court by the contraction of the posterior. After the lesion in the spinal cord has to some extent cleared up, the affected anterior muscles may remain more or less inactive from not having full play, consequent upon the fixation of the foot by the contracted posterior set. On the restoration of the foot following the division of the tendo Achillis, the anterior muscles are brought into action again, and any part of them that may not have undergone degenerative changes, and is in connection with a healthy nerve-centre, rapidly regains its lost strength.

What has already been said about talipes equinus in general especially applies to the paralytic form. Except in slight cases, in which electrical tests may be necessary to demonstrate the paralysis of one or more muscles, the wasting of the limb, the bluish-red congested appearance and coldness of the skin, and the history of the case, are usually sufficient to distinguish it from the other varieties of equinus. Electrical reaction will demonstrate accurately what muscles or groups of muscles are affected.

It may be added that when all the muscles of the leg and foot are paralyzed, the foot falls into the equinus position by its own weight and may either remain flail-like, and capable of being placed in any position, or it may become fixed in plantar-flexion by the contraction of the ligaments (Fig. 174).

Corns, pressure sores, and ulcers, over parts subjected to pressure, are common in paralytic equinus, especially when the paralysis is extensive.

(3) *Talipes Equinus resulting from Spastic Paraplegia, or Spastic Cerebral Paralysis.*—In patients suffering from the condition known as spastic paraplegia, or spastic cerebral paralysis, we occasionally meet with a form of talipes equinus. The equinus position is, as a rule, slight, and although dorsal flexion of the foot beyond a right angle is on first taking hold of the foot firmly resisted, yet on continuing the pressure the calf muscles gradually yield, allowing the foot to be fully dorsal-flexed. The muscles of the knees and hips are generally affected in a similar manner—that is, attempts to flex the knees and flex or abduct the thighs

are at first resisted; but if the pressure is continued the muscles gradually yield, as in the case of the feet. One or both of the upper extremities are also frequently involved, and the patient's mental condition is commonly defective.

(4) *Talipes Equinus following Pseudo-Hypertrophic Paralysis.* —In the later stages of pseudo-hypertrophic paralysis talipes equinus amongst other deformities is quite common. The accompanying illustration was taken from a cast of a patient suffering from that affection (Fig. 176).

FIG. 176.—PHOTOGRAPH OF A CAST OF THE LEFT FOOT AND LEG OF A CHILD EIGHT YEARS OLD SUFFERING FROM PSEUDO-HYPERTROPHIC PARALYSIS. (No. 97A, St. Bartholomew's Hospital Museum.)

The foot is in a position of marked equinus.

(5) *Reflex Talipes Equinus.*—Slight degrees of talipes equinus are said sometimes to arise as a reflex contraction of the posterior or plantar-flexor muscles, consequent upon irritation caused by derangement of the mucosa of the alimentary canal, whether from worms, impure food, or chronic inflammation. The irritation of a long narrow prepuce is also said at times to be a source of irritation which may act reflexly in this way. We have had no experience of these cases ourselves. Professor Sayre and others in America speak of phimosis as a not uncommon cause of spasmodic equinus.

(6) *Hysterical Talipes Equinus.*—Occasionally we meet with talipes equinus in hysterical patients. The chief interest in such cases lies in the question of diagnosis, to which section we refer for further information on this variety of equinus.

(7) *Compensatory Talipes Equinus.*—Where there is shortening of one limb from old hip disease or other cause, we sometimes meet with a condition of equinus brought about by the patient endeavouring to make up for the deficiency in the length of the limb by walking on the ball of the toes. Through constantly keeping the foot plantar-flexed, it becomes fixed by the shortened ligaments and muscles in the deformed position.

(8) *Adaptive Talipes Equinus, or Equinus from Position.*—Any ailment that entails a long period of lying on the back in bed may be indirectly a cause of talipes equinus. Under these circumstances, if sufficient attention is not paid to the patient, the weight of the bed-clothes may press upon the dorsum, and maintain the foot in a position of plantar flexion. The plantar-flexor muscles and ligaments may then contract to adapt themselves to the newly-assumed position of the foot, and talipes equinus result. Talipes equinus from position is perhaps most commonly met with in patients with hemiplegia. Here, on account of the paralysis of the muscles of the limb, the foot will more easily yield to the influence of position, weight, or pressure.

Except in the case of position from paralysis, no degeneration of the muscles takes place, and perfect restoration of the shape and function of the foot may be obtained by treatment.

Under the head of talipes equinus from position we might include those cases of infantile paralysis in which there is paralysis of the posterior as well as of the anterior muscles, and much shortening of one limb from arrest of growth consequent upon the paralysis. The foot in such cases falls into the position in equinus, as in Fig. 177, simply by reason of its own weight, and may either remain flail-like or become fixed by the contraction of the ligaments.

(9) *Talipes Equinus following Fracture.*—A badly-set Pott's fracture, or other fracture in the neighbourhood of the ankle-joint, may result in the foot assuming a position of talipes equinus. Dr. Little mentions a case of ankylosis of the ankle-joint in the equinus position resulting from fracture of the fibula and injury to

the ankle-joint. Many of these cases, however, are not instances of true equinus, since there is some backward dislocation of the foot as well as dorsal flexion.

(10) *Talipes Equinus resulting from Disease of the Ankle-joint.*—Following upon disease in or around the ankle-joint, the foot, in consequence of not having been kept at a right angle, may become ankylosed in the position of talipes equinus, the position

FIG. 177.—PHOTOGRAPH OF A PARTIALLY-DISSECTED SPECIMEN OF EQUINUS IN AN ADULT AFTER INFANTILE PARALYSIS IN INFANCY.

The right leg was much shorter than the left, and was not used in progression. All the muscles were fatty.

into which it has been allowed to drop by its own weight during the healing process. Perhaps the most common cause of ankylosis at the ankle with the foot in the equinus position is tubercular and rheumatic disease of the joint; but other inflammatory affections, as well as tubercular conditions of the joint and osteo-

arthritis, are occasionally causes. In such cases it is of some importance to determine whether the ankylosis is fibrous or bony, since upon this point the prognosis will to a great extent depend.

Rheumatic affections of the ligaments and fibrous tissues of the joint, more especially that form which sometimes occurs in the course of gonorrhœa, occasionally produce almost complete immobility of the joint, and if the foot has been kept plantar-flexed during treatment talipes equinus will naturally result.

(11) *Talipes Equinus following the Contraction of Cicatrices, etc.*—As a rare cause of talipes equinus may be mentioned the contraction of cicatrices following an abscess, wound, burn, or ulcer,

FIG. 178.—PHOTOGRAPH OF A SPECIMEN OF TALIPES EQUINUS FOLLOWING ULCERATION ON THE POSTERIOR PART OF THE LEG. (No. 3216D, St. Bartholomew's Hospital Museum; Male Surgical Registration Book, vol. iv. 91, 1449.)

in the region of the calf. Fig. 178 is an illustration of a case of equinus occurring as the result of a large chronic ulcer on the back of the lower part of the leg.

(12) *Talipes Equinus from Destruction of the Anterior Tendons or Muscles.*—In rare cases equinus may be brought about by de-

struction of the anterior tendons by ulceration on the front of the leg or ankle, or by wounds, burns, etc. Mr. Walsham has recently had such a case under his charge. Here as the result of a chronic ulcer over the lower third of the tibia, the anterior tendons were destroyed, and the foot in consequence took the equinus position.

## Diagnosis of Talipes Equinus.

Whenever the foot cannot be dorsal-flexed beyond a right angle with the line of the leg, talipes equinus may be said to exist. As regards diagnosis further than this, it is rather a question of diagnosing the variety of the equinus than diagnosing equinus from other deformities of the foot.

Slight cases of equinus, especially those known as rectangular talipes, or right-angled contraction of the tendo Achillis, are not always easy to detect and may be overlooked unless the surgeon is careful to keep the leg extended on the thigh by pressing the knee well back, whilst dorsal-flexing the foot. If this point is attended to, there will be practically no difficulty in diagnosing the condition. But if, on the other hand, the examination is made with the leg flexed at the knee, the calf muscles are relaxed, and more dorsal flexion being then permitted, the right-angled contraction may escape notice.

Right-angled contraction is most often met with in cases of slight anterior paralysis, mild forms of spastic paraplegia, and in hysteria.

In cases of spastic paraplegia the muscles will be found to yield on continuous steady pressure, and the foot, although apparently fixed at a right angle to the leg, can be dorsal-flexed some way beyond this. The spasticity of the muscles of the thigh on flexing the knees, and of the adductors on attempting to abduct the thighs, should attract the surgeon's attention; whilst the history of the case, a probable concomitant spastic condition of one or more of the muscles of the upper extremity, the defective mental state of the patient, the absence of wasting and of the cold bluish-red condition of the limbs present in infantile paralysis, should serve for the diagnosis.

Hysterical cases may present some difficulty, but there is one point common to nearly all hysterical conditions of the feet,

namely, that on attempts at reduction non-persistent ankle-clonus is set up. Patients then lose control over their muscles, and allow reduction to be more easily performed. Again, if attempts at reduction fail from absence of clonus or from other causes, the following plan will be of use: Let the patient stand upright, with the heels together and the toes turned out. Keeping the heels on the ground, she should then be directed to flex, the ankles knees and thighs, and endeavour with her body upright and arms to her sides to touch the ground with her finger-tips. If there is any amount of organic contraction of the tendo Achillis, the patient will be unable to keep the heels on the ground; but if able to do so, it is a proof that there is an absence, at any rate, of much contraction. In hysterical cases there will also be absence of wasting of the limb, and the foot will be dorsal-flexed under the influence of electrical stimulation of the anterior muscles. Moreover, the history of the case and the presence of concomitant signs of hysteria will be of help; whilst an anæsthetic will prove the absence of any organic contraction of the tendo Achillis.

When the equinus is the result of disease in or around the ankle-joint, there will be sufficient evidence of the cause of the deformity, and it will only remain for the surgeon to diagnose whether the ankylosis is bony or fibrous.

In equinus from position, from contraction of cicatrices, or as the result of hemiplegia, the nature of the variety will be evident.

Electrical reaction will give reliable information as to the present state of the different muscles, and will show whether any paralysis is present, and if so what muscles are affected.

### Prognosis of Talipes Equinus.

The prognosis will depend on the cause of the deformity. *In congenital cases*, arguing from congenital varus, it should be good if the patient is seen sufficiently early. But if the case is neglected, though a complete cure may still be obtained, as in varus, by long perseverance in treatment, it is more probable that the result will not be absolutely satisfactory, and that some bone operation will be necessary to completely restore the foot.

In the *common variety* of *equinus*—that due to infantile paralysis—a complete cure, from the very nature of the case, cannot, of course, be obtained, though much may be done to enable the patient to walk by means of instruments. The amount of usefulness of the limb that can be promised will necessarily depend upon the severity and extent of paralysis. When one or more of the anterior muscles have been but slightly affected, and the deformity consists merely of a right-angled contraction, a very favourable prognosis may be given; whilst, on the other hand, where all the muscles of the limb are paralyzed, and the foot and leg is flail-like, the outlook is especially bad, though even in such a case something may be done, if some of the muscles passing between the pelvis and the thigh are intact, to enable the patient to walk without a crutch. Between these extreme conditions very various combinations of paralysis of the muscles of the limb may be met with in connection with the equinus deformity. The prognosis will then depend on the condition of the muscles moving the knee and hip, on the length of the limb, and on the presence or absence of paralytic sores or ulcers.

A question the surgeon is sure to be asked is the probability of a relapse after the restoration of the foot by division of the tendo Achillis. When the anterior muscles are completely paralyzed, a relapse is nearly sure to occur unless the patient is in such a condition of life as to procure efficient mechanical apparatus. But where the paralysis of the anterior muscles is less extensive, after the division of the tendo Achillis, what is left of the muscular tissue, through being brought into play by the rectification of the foot, may be much improved, and even without the use of an instrument no relapse may occur.

In the *equinus accompanying spastic paraplegia and pseudo-hypertrophic paralysis* the prognosis is necessarily unfavourable. In the former disease, however, tenotomy is sometimes of service, and in the latter tenotomy may also be useful as a palliative.

*In equinus from position*, seeing that the muscles are intact, complete restoration of the foot to its normal shape and functions can be promised. Again, in *compensatory equinus*, the foot can be completely restored to its normal position if thought desirable.

In *reflex equinus*, and in the *hysterical form*, the prognosis is, of course, favourable.

In *equinus following* fracture about the ankle, contraction of the calf muscles due to wounds, burns, etc., destruction of the anterior tendons from like causes, and ankylosis of the ankle-joint, the prognosis will depend upon the condition of the parts, and such general surgical considerations as cannot be entered on here.

## CHAPTER VII.

### TREATMENT OF TALIPES EQUINUS.

SEEING upon how many and various conditions talipes equinus may depend, it necessarily follows that somewhat different measures are advisable according to the cause of the deformity. In all forms the indications are (1) to restore the foot to its normal shape and functions as quickly as possible, and (2) to retain it in the restored position by certain physiological after-treatment, combined, if necessary, with mechanical apparatus.

**Various Methods of restoring the Foot to its Normal Shape and Functions.**—We will first discuss generally the methods that may be adopted for restoring the foot to its natural shape and functions, and, secondly, pass on to consider which of these methods is especially applicable to the individual forms.

The general methods of treating talipes equinus may be said to be (1) manipulative; (2) mechanical; (3) forcible rectification; (4) operative.

(1) **Manipulative Treatment** has for its object the stretching of the contracted tendons and ligaments, and the restoration of the normal movements of the joints. Alone it is only applicable to very slight cases, as some forms of right-angled contraction of the tendo Achillis in children, but combined with other methods it is of great service in promoting the return of healthy movements in the ankle and other joints of the foot, and in improving the nutrition of the wasted muscles. It is of especial use in those cases where there is thickening of the tissues about the joint, and adhesions in and around the joint-cavity, *i.e.*, in cases of talipes equinus depending upon old joint injury or disease. Manipulative treatment may be divided into passive movements of the joint, the various kneading, flicking and rubbing movements of

massage, and certain exercises to be undertaken by the patient himself.

In performing the passive movements, the leg should be grasped above the ankle gently but firmly with the left hand, whilst the foot is pressed upwards as far as it will go with the right hand. It should be held in this position for a few minutes, and then extended and the manipulation repeated. Next, the foot should in the same way be placed in the position of abduction, and thus held for a few minutes, and then in the position of adduction. Taking hold of the foot nearer the toes, the forepart of the foot should be forcibly but gently pressed upwards to overcome the contraction of the fascia, ligaments, and muscles in the sole, whilst, lastly, it should be carried through the movements of circumduction, first in an inward and then in an outward direction. The above movements having been completed, the manipulation should be repeated, and kept up for ten minutes or so at a time. The mother, or an intelligent nurse, can readily undertake the manipulation after having had two or three lessons. But the surgeon should from time to time see that the passive movements are being properly carried out. If the expense of a trained masseuse is no object, it is well that one should be employed.

*The rubbings*, *flickings*, and *kneadings* should be applied to the muscles of the leg and foot as well as around the ankle. Any muscles obviously small and wasted, or which show alteration to electrical reaction, should be especially treated; but all the muscles will be benefited by the massage treatment.

The *exercises* we have found especially useful are the following: The patient stands with the soles flat on the ground, the foot of course being bare, and then bending the knees and hips whilst holding the body erect, with the arms close to the side, endeavours to touch the ground with the finger-tips. In this way, in the attempt to dorsal-flex the ankle, the tendo Achillis, and to a less extent the posterior ligaments, are put on the stretch. This exercise should be performed, say, six times a day, at regular intervals, and for five or ten minutes at a time. If persevered in for many months, some elongation of the contracted tissues can be obtained. This exercise may be varied by placing a wedge-shaped block of wood, or other non-yielding material, two and a half to three inches high, beneath the fore part of the foot, and

then in like manner whilst bending the knees and hips and keeping the body erect, endeavouring to touch the ground with the tips of the fingers.

Another exercise can be done by the patient sitting on a chair with the legs stretched at full length and the heels on the ground, whilst he pulls on the fore part of the foot with a cord passed round the ball of the toes.

Fig. 161 shows the leg and foot of a patient cured by manipulation and exercises, but it is only for slight cases such as this that the treatment is alone sufficient.

(2) **Mechanical Treatment.**—Under this head are included (1) the plaster bandage, (2) elastic extension, and (3) lever, screw, and cog-wheel apparatus. The various methods have all for their object the stretching of the shortened tendo Achillis and contracted ligaments. We do not say that in slight cases mechanical apparatus alone may not succeed in restoring the foot, but we do say that it takes so long, and entails so much unnecessary, as we think, expense, that without some form of operative treatment we do not deem it advisable. In severe cases, we doubt if it can alone ever be successful. The mechanical apparatus we have nearly always employed is the plaster of Paris bandage. We have used most of the other methods described here, but have not found them to have any special advantage over plaster in the majority of cases.

1. *Plaster of Paris Bandage.*—This is invariably used by us for immobilizing the foot and retaining it in the restored position after the division of the tendo Achillis, plantar fascia, or other operative measure that may have been employed.

Before applying the plaster it is our custom to place the foot at once in the best position to which it can be forced, irrespective of the amount of separation that this may necessitate of the divided ends of the tendon. We may here incidentally say that, although as much as two inches has been left between the divided ends of the tendon, no mishap or non-union, or even weak union, has occurred (Fig. 167). The details as to the way the plaster bandage should be applied are given under the treatment of talipes varus at p. 146. The advantages, as we conceive them, of plaster of Paris bandaging over other methods of mechanical treatment are there fully entered into. On the completion of the plaster treat-

ment, the mechanical and physiological after-treatment that may be necessary is described at p. 311.

Whilst the plaster treatment is in progress manipulative treatment (p. 294) may, with the greatest advantage, be used before each reapplication of the plaster bandage. Where this can be carried out effectually it is advisable, after the first application of the plaster, to remove it and reapply it two or three times instead of only once a week.

In our out-patient practice the plaster bandage, which is always applied over a thick cotton-wool bandage wound round the foot, ankle, and calf, nearly as high as the knee, is kept on for a week. At the end of that time it is removed, and reapplied if the foot is in a good position, and kept on another week or ten days, or longer in paralytic cases. If the foot on removal of the plaster cannot be dorsiflexed to an equal degree with the sound foot, the foot is forced into a better position, and thus held till the plaster is reapplied and is firmly set. It is again removed, and the foot further rectified weekly till the desired amount of dorsal flexion is obtained.

In severe cases it may be necessary to redivide the tendo Achillis before the foot can be brought into a satisfactory condition.

2. *Elastic Tension.*—This has for its object the gradual stretching of the shortened tendon and ligaments. Like other forms of mechanical treatment, it should as a rule, in our opinion, be only applied as an adjunct to the more effectual and rapid operative measures. The methods of applying elastic tension are very numerous. Amongst these may be mentioned the following:

(*a*) *Heidenhain's Apparatus* (Fig. 179) consists in intercalating an elastic ring in a bandage suitably fixed, as shown in the figure, over the front of the foot and around the knee. It is of use in some spastic and paralytic cases.

(*b*) *Marshall's Apparatus* (see p. 158) may also be used in cases of equinus in children. It is described in detail under talipes varus.

(*c*) *Stromeyer's Apparatus* (Fig. 180) is not often, we believe, used in this country. It is, however, an effective apparatus, and is said by Hoffa to be one of the best-known forms in use in

Germany. The chief objection to it is that it necessitates the patient remaining in bed or on a couch.

(*d*) *Hoffa's Apparatus.*—Hoffa recommends a combination of elastic tension with plaster of Paris bandages. A reference to

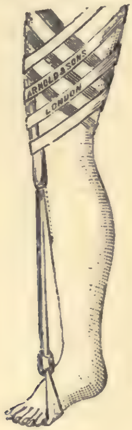



FIG. 179.—HEIDENHAIN'S APPARATUS FOR ELASTIC TENSION.

Fig. 181, taken from Hoffa's work,* will explain the method of application and arrangement of the apparatus. The difficulty of adjustment somewhat militates against it.

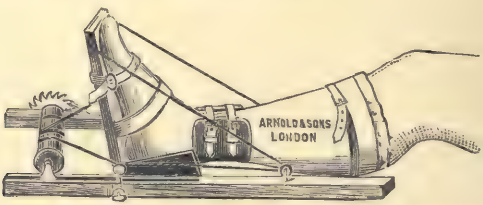



FIG. 180.—STROMEYER'S APPARATUS.

3. *Screw, Cogwheel, and Lever Apparatus.*—Very various and numerous contrivances coming under the above category have been invented for the gradual stretching of the contracted tendon. Indeed, there are probably few orthopædic surgeons who have not their own special apparatus for the purpose.

* Hoffa, *op. cit.*, p. 678.

Amongst these we select for description the following; but for our own part, as already stated, we prefer simple extension by means of the plaster of Paris bandage.

First we may mention the old Scarpa's shoe and its various modifications. This was long used, not only in talipes varus, but also in talipes equinus, and is still used in its modified forms by some surgeons at the present day. Adams' adaptation is perhaps the best. When we have employed a cogwheel apparatus, this is the one we have selected. It is illustrated under varus at p. 167. A more modern contrivance is that known as *Shaffer's apparatus* (Fig. 182). It consists of a calf-band and two uprights, with a heel-cup and sole-plate. The motion is obtained by an endless worm and screw moving the whole foot-piece. The sole-plate is divided transversely, opposite the transverse tarsal joint, the anterior and

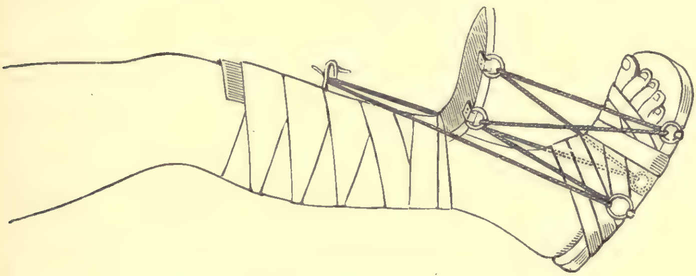


FIG. 181.—HOFFA'S APPARATUS.

posterior part of the plate being connected by a traction-rod with ratchet movement. The foot is fixed to the sole-plate by straps, one round the heel and another over the astragalus, as shown in the figure. The action of the apparatus is thus described by Messrs. Bradford and Lovett*: The ankle-joint of the shoe is set to fit the deformity (A). By tightening the straps the foot is pulled down on the shoe. The strap over the head of the astragalus is then loosened, to allow it to rotate; and by the key the foot is brought to a right angle. Then the forward part of the sole-plate is separated from the other, thus pulling on the heel traction strap; and the heel is thus irresistibly drawn downwards and forwards. Shaffer states that a temporary gain of $\frac{1}{8}$ to $\frac{1}{4}$ of

* Bradford and Lovett's 'Orthopædic Surgery'; New York, 1890.

an inch in the length of the foot is not unusual after a single sitting of fifteen minutes.

(3) **Forcible Rectification.** — Forcible rectification consists in forcing the foot into the best possible position either at one or at several sittings, and then retaining it in this position by means of plaster of Paris or other mechanical appliances. It is employed either with or without the previous division of the tendo

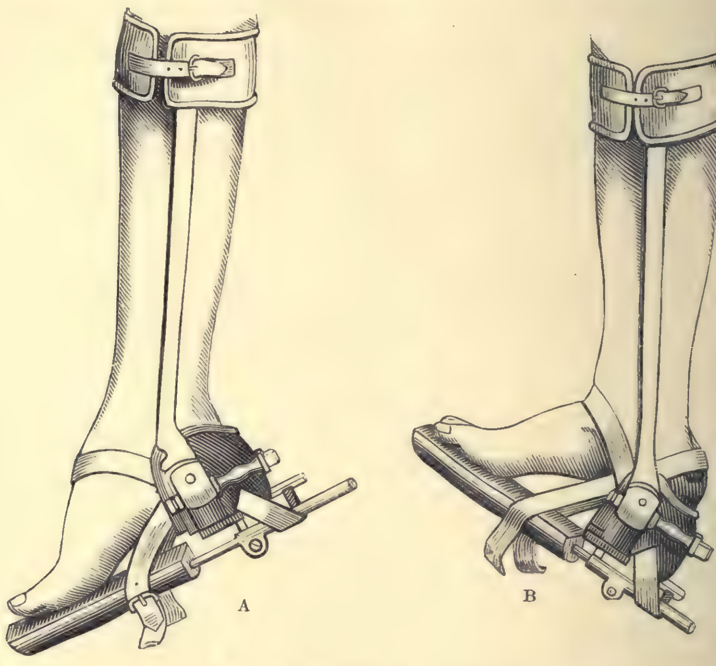



FIG. 182.—SHAFFER'S APPARATUS.
A, When first put on ; B, with force applied.

Achillis and plantar fascia, and by some surgeons is combined with subcutaneous division of the posterior ligament of the ankle-joint, and by others, in addition, with the division of any resisting structures that may be felt in the sole of the foot.

Forcible rectification may be considered under the heads of Manual Forcible Rectification and Instrumental Forcible Rectification.

*Manual Forcible Rectification.*—The patient having been placed under an anæsthetic, the surgeon takes hold of the foot and forcibly dorsal-flexes it. In young children care must be taken not to use sufficient force to cause a separation of the lower epiphysis of the tibia. Before making use of forcible rectification, we have almost invariably divided the tendo Achillis, and, if contracted, the plantar fascia and any other tense bands or tissues felt in the sole. At times we have also divided the posterior ligament of the ankle subcutaneously. As stated elsewhere, this ligament is difficult to divide effectually, and, save in exceptional cases, we do not think much must be expected from the operation.

After the foot has been wrenched into the best possible position, it may be placed in plaster of Paris, or, if preferred, in some other retentive apparatus. The plaster or other retentive apparatus should be kept on for a week, and at the end of that time removed, the rectification repeated and the plaster reapplied.

When the foot has been brought into the best obtainable position, mechanical and physiological after-treatment should, if necessary, be carried out as described at p. 311.

*Instrumental Forcible Rectification.*—Many contrivances have been invented for forcibly correcting the equinus position of the foot. A description of some of the chief will be found on p. 174, under 'Forcible Rectification of Varus.' Forcible rectification is applied by some surgeons without previous tenotomy of the tendo Achillis or plantar fascia. It is better, however, to divide these structures before the apparatus is applied, as the force will then be concentrated on the ligaments. Further, if after division of the tendon and fascia the foot can be rectified, there is, of course, no call for the application of any force. After the operation the foot can either be secured in plaster of Paris, as previously described, or in some other form of retentive apparatus. But what has been said of the after-treatment after the application of manual force applies equally to that after instrumental.

(4) **Operative Treatment.**—Under the head of operative treatment is included (1) *tenotomy*, or the division of the tendo Achillis, plantar fascia, and tendinous and muscular tissues in the sole of

the foot; (2) *syndesmotomy*, or the division of ligaments; (3) *osteotomy*; (4) *arthrodesis*, or the production of ankylosis at the ankle-joint.

1. *Tenotomy*.—Division of the tendo Achillis, except, perhaps, in very slight cases of right-angled talipes in young children, and in some paralytic cases with much shortening of the affected limb, is nearly always desirable; and in many cases is in itself sufficient to cure the deformity. Thus, in equinus from position after the division of this tendon, the foot can, as a rule, be at once restored, and, having been kept at rest for a week or ten days to allow the divided tendon to heal, the patient may use his limb for progression as usual. In paralytic cases the foot can also, as a rule, at once and quite safely be rectified, though as much as an inch or more of space is left between the divided ends of the tendon. Even when a gap of two inches has been left, we have invariably found the tendon united, on the removal of the bandage at the end of a week, by an abundance of newly-formed tissue, and in such a case have allowed the patient to walk at the end of a fortnight or three weeks (Fig. 167).

When cavus exists along with equinus, it is, in our opinion, certainly advantageous to cure it (as advised by Little and Adams) before attempting to overcome the equinus, especially if immediate rectification is employed, as, if the tendo Achillis is cut at the same time as the plantar fascia, the heel cannot be used as a *point de puits* in straightening out the plantar arch. To cure the cavus it may be only necessary to divide the plantar fascia in the manner described on p. 202, where full details of the operation and after-treatment will be found. When the cavus has thus been overcome, the equinus may be attacked by dividing the tendo Achillis.

In right-angled contraction of the tendo Achillis, or rectangular talipes as it is sometimes called, there may be some question as to the propriety of dividing the tendo Achillis. In young children the tendon can certainly be stretched by judicious exercises and manipulation; but all this takes some time, and seeing how successful and simple an operation the subcutaneous section of the tendo Achillis is, we hold that, as a rule, it ought to be done. If the patient is allowed to remain with the deformity untreated, he is continually catching his toe, and is in

danger of falling. He walks, moreover, especially if both feet are affected, with an awkward gait.

2. *Syndesmotomy.*—The division of the posterior ligament of the ankle-joint may occasionally be required. We have rarely, however, met with a case of equinus in which this appeared to us to be necessary. The division of the calcaneo-scaphoid and calcaneo-cuboid ligaments can hardly ever be called for. In the few cases in which it has appeared that something might be gained by their division, the bones have been so altered in form, and their articular surfaces so modified by the long continuance of the deformity, that we have found that an osteotomy or an amputation was required. We may here mention that in these severe cases there is generally so much shortening of the limb that the latter operation has generally been desired by the patient.

The methods of dividing these ligaments is described in detail at p. 210.

3. *Osteotomy.*—Under this head is included tarsotomy, or the cutting across of the tarsus, and tarsectomy, or the removal of a portion of the tarsus. Both operations have been performed in intractable cases of talipes equinus.

*Tarsotomy* may be done either with the chain-saw or with an Adams' or Davy's saw, in the way described under varus at p. 219. This operation, however, does not commend itself to our judgment. In severe cases we have not found the mere cutting across the tarsus sufficient to allow the bones to be brought into a good position, and in less severe cases milder measures have sufficed.

*Tarsectomy*, or the removal of a portion of the tarsus, is a more useful measure than tarsotomy, but still not one that we think is often indicated. Perhaps the forms of tarsectomy most often employed are the removal of a wedge from the tarsus, with the apex towards the sole, or the ablation of the astragalus. But the removal of a wedge from the neck of the astragalus, the resection of the head of the astragalus, and other similar procedures, have been employed in equinus as well as in varus. For a description of these operations the reader is referred to p. 221.

Here we would only remark that all bone operations should be reserved for severe and inveterate cases where other and milder methods of treatment have been tried and failed, or where, from

the severity of the case, it is self-evident that nothing short of the removal of bone can suffice for the rectification of the foot. In many of these extreme cases amputation will be found preferable to a tarsectomy, in that a sufficiently useful foot by these means may not be obtained. For labourers a sound stump and solid wooden leg is of more service than a restored, but weakened foot. The amount of shortening necessitating as it does the expense of a high boot is with them, moreover, a serious consideration.

4. *Arthrodesis*, or the production of ankylosis at the ankle-joint, is an operation that is sometimes advisable in severe paralytic cases, in which the foot, in consequence of all the muscles of the leg being affected, is flail-like and useless. The operation consists in a partial resection of the ankle-joint—in short, of denudation of the bones of their cartilage—in order that ankylosis may ensue.

There are several ways of performing the operation. On the whole, the method by a curved external incision appears the best. The strong deltoid ligament should be spared; when this is divided the ankle is weakened, since fibrous rather than osseous ankylosis is more common after resection of this joint.

*Operation.*—Having prepared the foot for operation as previously described, and applied an Esmarch's bandage, the tendo Achillis should be first divided, since this procedure not only facilitates the correction of deformity, if such exists, but aids the dislocation of the foot inwards, and renders unnecessary the division and subsequent suture of the peronei. An incision about four inches in length is next made along the posterior border of the fibula, under the external malleolus, and then obliquely forwards and inwards as far as the medio-tarsal joint. The peronei being drawn aside, the periosteum and ligaments are detached from the external malleolus. With a little force the foot can now be dislocated inwards and the ankle-joint fully exposed. The cartilages should next be removed from the bones by means of Volkmann's spoons, gouges, etc., as is found most convenient, the wound well washed with some antiseptic to free it from *débris*, the foot placed at a right angle with the leg, and the wound then closed by deep and superficial sutures. Wiring or pegging the bones together does not seem necessary. The foot and ankle may

now be placed in a plaster bandage or secured on a back-splint with a foot-piece. The Esmarch's bandage should not be removed till the dressings and plaster of Paris bandage have been applied. The dressings and plaster bandage may, under favourable circumstances, be left on for a month, and then changed and reapplied till the parts have consolidated and firm ankylosis has ensued.

This operation is indicated when the paralysis of the leg muscles is complete, the foot flail-like and useless, and instruments are beyond the reach of the patient. It may also be useful in some cases in which the deformity is irreducible and has resisted tenotomies and orthopædic appliances.

**Treatment applicable to the Various Forms of Talipes Equinus.**

*The Congenital Variety.*—For slight cases manipulation combined with mechanical rectification by means of plaster of Paris or other apparatus may suffice. This, however, should not be too long persevered in, but the tendo Achillis divided if the foot does not soon yield. In all severe grades division of the tendo Achillis and immediate extension in plaster of Paris should be employed at once, whilst if tense the plantar fascia may also be divided at the same time. After the foot has been brought into good position, a relapse should be guarded against, till the patient is able to walk, by efficient physiological after-treatment and the employment of a boot with extension apparatus, such as shown in Figs. 148, 151. A night-shoe (Figs. 93, 94) should also be worn for some six to twelve months.

When the equinus is very severe, division of the tendo Achillis, and even of the posterior ligament, may not be sufficient to restore the foot to the normal position, or even to bring it up to a right angle with the leg. In such, after mechanical measures have been employed systematically and thoroughly, the removal of the neck of the astragalus, or the whole of the astragalus, or a wedge-shaped piece with the apex downwards from the tarsus, may have to be resorted to.

*The Paralytic Variety.*—These are the cases that come most frequently under the care of the surgeon. The treatment here will depend in great part on the length of the leg, the condition

of the muscles, the condition of the skin, the extent of the paralysis, and the presence or absence of ulcers and corns.

As previously stated, every degree of paralysis may be met with, from paralysis of a single muscle or part of a muscle, to complete paralysis of the whole lower limb, or indeed, in exceptional cases, of both lower limbs, or of one or both of the upper limbs as well.

When only one or two muscles or portions of muscles of the leg and foot are affected, beyond rectifying the foot in one of the ways before indicated no mechanical after-treatment may be necessary; but massage and electricity of the affected muscles may be of considerable service.

When the whole of the anterior muscles or considerable portions of them are affected, a boot with leg-irons and toe-raising

FIG. 183.—BOOT FOR TALIPES EQUINUS.

The dotted line shows the position of the wedge-shaped pad to compensate for the raised heel.

spring of some form or other (p. 213) should be employed, after division of the tendo Achillis and rectification, to counteract the tendency of the foot to be drawn or to fall back into the equinus position; and under some circumstances a stop-joint may be used at the ankle to prevent the foot passing into plantar flexion beyond a right angle. We prefer, however, a free joint at the ankle and the toe-raising spring, since the stop-joint interferes with free plantar flexion in walking, and, at the best, only prevents the foot passing the right angle. The spring, on the other hand, if effective, tends to prevent the foot reassuming the faulty position, and at the same time allows more muscular play.

Some surgeons advise that the tendo Achillis had better be left

intact in paralytic cases. They argue that in its contracted state it holds the foot firmer, and that the equinus position of the foot compensates for the shortening of the leg. When this view of the case is taken, a wedge-shaped pad is placed within the boot to compensate for the raised heel, as shown in Fig. 183, or the O'Connor extension may be worn (Fig. 185). In some severe cases, where there is much shortening of the paralyzed limb and the whole limb is wasted and atrophied, this is no doubt an excellent method of treatment, in that it causes less inconvenience than would the very high and clumsy boot that must otherwise be worn (Fig. 184). In less severe cases, however,


Fig. 184.—High Boot for the Treatment of Short Leg.

In talipes equinus of paralytic origin it is seldom that such an increase in the thickness of the sole is necessary as shown in the figure.

although there may be shortening of the limb to the extent of an inch to an inch and a half, or even more, we prefer to divide the Achillis tendon. The arguments in favour of division are well stated by Mr. Adams, and since they fully accord with our views, we state them *in extenso.*

'First, in the great majority of cases the paralysis is limited to a few muscles, viz., those on the anterior aspect of the leg, and these are often very unequally affected. When the extensor communis is completely paralyzed, the anterior tibial and extensor pollicis frequently retain a considerable amount of power; the

anterior tibial sometimes escapes altogether when the other muscles are paralyzed, or, on the other hand, it may be the only muscle paralyzed.

'By allowing the deformity to continue, atrophy is induced or increased in the comparatively healthy muscles on the anterior part of the leg, as well as in the great muscles of the calf, in consequence of the motion at the ankle-joint being either limited or entirely prevented by the contraction. Thus, the muscular structures of the leg are still further damaged by the persistence of the deformity.

'Secondly, if, while the deformity continues, there should be any return of power in the paralyzed muscles, it will not be available, as dorsal flexion of the ankle-joint cannot take place. It has been previously stated that complete recovery is the rule in cases of slight infantile paralysis, and that partial recovery is almost constant, and to this circumstance we must refer the large number of cases of talipes equinus we meet with in which the muscles are in a healthy or nearly healthy condition, the foundation of the mischief in these cases having been laid by the partial paralysis of a few muscles. Thus, the persistence of the deformity interferes with the natural process of recovery in the paralyzed muscles, and prevents the free play of such muscular power as exists. Moreover, in practice it is found that the restoration of power is materially assisted by the removal of the contraction.

'Thirdly, structural changes in the joint, such as thinning and irregular removal of articular cartilage, and adapted shortening of the ligaments of the joint, take place by the continuance of the deformity, thus rendering the cure more difficult and less perfect in proportion to the delay.

'Fourthly, the serious effects and inconveniences certain to arise from the continuance of the deformity when severe—viz., extreme lameness when one foot is affected, and total inability to walk when both feet are affected, curvature of the spine, etc.—render it absolutely necessary that the deformity should be removed.

'For the reasons above given, it is advisable to remove the deformity when severe, in cases of talipes equinus in which paralysis still exists, whatever may be the extent of the paralysis, and the benefit to the patient will be in proportion to the severity of the case and the length of time the paralysis has existed ; but

as respects the ultimate condition of the limb, as to the restoration of muscular power, the gain will be in proportion to the early period at which the operation be performed, after the contraction has become confirmed. No benefit will result from operation in cases of slight contraction with much paralysis.'

*The Spastic Variety.*—In this form some difference of opinion exists as to the propriety of dividing the tendo Achillis. In the few cases in which we have done the operation, some good has certainly seemed to have followed at the time, but we are unable to say if a relapse has subsequently taken place. Exercise and massage may also be employed, but the prognosis is not very hopeful at the best.

FIG. 185.—THE O'CONNOR EXTENSION APPARATUS READY FOR USE.

*In Talipes Equinus following Pseudo-Hypertrophic Paralysis*, the division of the contracted tendons and the use of an instrument will be of temporary service in enabling the patient to get about for awhile.

*The Reflex Variety.*—The source of reflex irritation should of course, if possible, be removed (see p. 286). Circumcision should be done when the irritation appears to proceed from a long prepuce.

*The Hysterical Variety.*—The ordinary hysterical remedies and moral persuasion will be here useful, combined in some cases with forcing the foot into position, and fixing it thus in laster of

Paris. We have found the galvanic battery useful in a few instances.

*In the Compensatory Variety of Talipes Equinus*, the O'Connor extension apparatus (Figs. 185, 186) is very suitable; certainly in many cases it is better than the division of the tendo Achillis and a high boot, which would be the other alternative. This apparatus is not applicable where the shortening is less than three or four inches.


FIG. 186.—THE O'CONNOR EXTENSION APPARATUS APPLIED.

A shows the position of the foot in the extension apparatus, a sock or stocking being worn as usual within it. It will be noticed that the foot is resting as indicated by a dotted line upon a platform which is made exactly to the required height. In B the extension apparatus is hidden by a stocking drawn over it, and an ordinary shoe adjusted, so that the foot of the shortened limb resembles the other.

*In Talipes Equinus from Position*, mechanical extension, if the plantar flexion is not marked, will generally succeed; but if the foot does not soon yield, the tendo Achillis should be divided and the foot at once placed in plaster of Paris.

*In Talipes Equinus following Pott's Fracture*, or other fracture about the ankle-joint, if wrenching of the foot under chloroform and division of the tendo Achillis fail, an osteotomy of the fibula, or of the tibia above the malleoli, or of both, or removal of a wedge of bone from one of these situations, according to the nature of the fracture, will often succeed in giving the patient a very useful foot.

A case of equinus the result of a Pott's fracture badly set at Honfleur was recently under the care of Mr. Walsham in St. Bartholomew's Hospital. The patient, a woman aged forty-four, was unable to put the heel to the ground. The foot was in a position of marked plantar flexion, and the movements of the ankle-joint were much impaired. The equinus in this case was corrected by division of the tendo Achillis, forcible wrenching in the direction of dorsal flexion, and the subsequent use of a modified Scarpa's shoe.

*In Talipes Equinus resulting from Disease of the Ankle-joint* cautious wrenching under chloroform, with division of the tendo Achillis if necessary, may overcome the plantar flexion if the equinus is merely the result of fibrous ankylosis. It need hardly be said that such an operation should not be undertaken whilst there is any danger of relighting up the disease. When the bad position is the result of bony ankylosis, a judiciously-planned osteotomy may at times enable the surgeon to place the foot at a right angle with the leg.

*In Talipes Equinus following the Contraction of Large Ulcers at the Back of the Leg, or the Destruction of the Anterior Tendons*, amputation will probably be called for. Such cases are, fortunately, rare.

**After-Treatment.** — To fulfil the second indication of maintaining the foot in the restored position, by promoting the function of the joint, and the nutrition of the muscles, it is necessary to employ both mechanical and physiological after-treatment.

(1) *Mechanical After-Treatment.*—It is only in certain cases, as the paralytic, that mechanical after-treatment is necessary. The object of the treatment is to prevent a relapse, and to help the muscles to hold the foot in the normal position. In paralytic cases a relapse is sure to follow unless some mechanical apparatus

is worn; indeed, it only too frequently occurs in spite of this precaution. To some extent, however, a relapse under these circumstances must be attributed to neglect on the part of the patient or his friends. After a few months the apparatus is frequently allowed to get out of order. Leather stretches and tears, and thus straps yield or are dispensed with; screws become loose, or fall out and are lost; springs snap, or get rusty for want of oil; or other accidents may happen. Too frequently, therefore, amongst the poor attending the out-patient rooms relapses occur.

Where, however, the apparatus is carefully looked after, much can be done to prevent a return of the deformity, and where efficient physiological after-treatment is systematically employed, and the paralysis has not been extensive, what muscular tissue is left may so far regain its function that a return of the deformity, with moderate care, may be prevented.

Broadly put, the mechanical after-treatment may be said to consist in the employment of a walking-boot, with leg-irons reaching to the knee, or to the thigh, or to the pelvis, according to the extent of the paralysis, and some form of spring or elastic apparatus, so arranged as to compensate, as far as possible, for the paralyzed muscles. The form of instrument we are accustomed to use for an ordinary case of equinus following on paralysis of the extensor muscles is shown in Fig. 187. It consists of a walking-boot with leg-irons, which are double below the knee, the outside iron being continued upwards, if necessary, to the thigh or pelvis (Fig. 135). The leg-irons are either fixed permanently into the sole of the boot, as in Fig. 136, or they are inserted into square sockets fixed in the heel (Fig. 139). The advantages of the latter plan are, that the boot can be changed without the inconvenience of removing the whole instrument, and when a boot is worn out another can be fitted without having the whole instrument removed, or the patient in the least deprived of it whilst the new boot is being fitted to it. The objection to it, and one which applies more especially to the class of patients attending hospital practice, is that the socket is apt with wear to become too large for the iron. The iron or irons are then continually slipping out from the sockets, and the patient being only too apt to wear the apparatus in this condition, more harm than good is the result. When expense is not an object the joint shown in Fig. 138 may

be employed to enable the patient to change the boot without taking off the irons.

At the ankle we usually employ a free joint; some surgeons, however, prefer a stop-joint to prevent the foot being carried in the direction of plantar flexion beyond a right angle. This contrivance in some forms of paralysis is certainly useful, but for ordinary cases we prefer a free joint and spring.

In measuring for the instrument, the surgeon should be careful to indicate the position of the joint in the iron, so that it may accurately correspond with the centre of motion in the ankle-joint. It is often placed too low, the tip of the malleolus being


FIG. 187.—INSTRUMENT USED IN THE AFTER-TREATMENT OF TALIPES EQUINUS OF PARALYTIC ORIGIN.

The toe-raising spring on the outer side of the boot and outer iron is to compensate for the paralysis of the anterior muscles.

given in the measurements as the spot for the joint. The centre of motion in the ankle-joint is, of course, higher than this, and may fairly well be arrived at by taking a point about half an inch to three-quarters of an inch above the tip of the malleolus.

The leg-irons should be properly shaped, so as in some measure to correspond with the outline of the leg, and should be fixed above to a well-padded calf-circlet, secured when *in situ* by a

strap and buckle and sliding-piece of steel. To the outside iron a steel spring is fixed, in a way that will be readily understood by reference to Fig. 187. This spring tends to continually draw the boot with the foot towards a position of dorsal flexion. It is intended to take the place of the paralyzed extensor muscles and counteract the tendency of the unbalanced flexors to draw the foot into the equinus position, or the tendency of the foot unsupported by the extensors to fall into this position.* The spring should be sufficiently strong to dorsal-flex the foot when the calf muscles are relaxed, but not so strong that the calf muscles when contracting are unable to overcome its resistance,

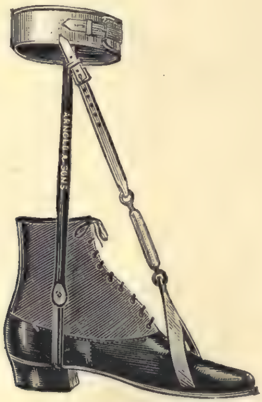



FIG. 188.—BOOT FOR EQUINUS WITH LEG-IRON AND RUBBER ACCUMULATOR.

or in doing so are subjected to unnecessary strain. Considerable nicety is required in properly adjusting this spring, or, indeed, any form of spring, so that this end is obtained. Care and attention on the part of the parents are also essential to see that it is kept well oiled, and generally in a working condition. But too frequently in hospital work the spring, from lack of attention, is more often than not found, after a week or two, to be exercising practically little influence on the movements of the foot at the ankle.

Many other forms of spring are in use, and may be seen illus-

* Some difference of opinion exists as to the cause of the foot in paralysis of the extensors assuming the equinus position. This is discussed at p. 284.

trated in the catalogues of the surgical instrument makers. We have tried, at one time or another, all or nearly all of them, and, on the whole, have been most satisfied with the one here shown. As a substitute for a spring, a strap attached to the toe of the boot and the calf-circlet may be employed, the traction being here provided by a rubber accumulator intercalated in the strap (Fig. 188). Or a simple rubber ring may be used instead of the rubber accumulator. In the figure only an outside leg-iron is shown. We usually prefer double irons, however, as the foot by such is held better in position with the bones of the leg.

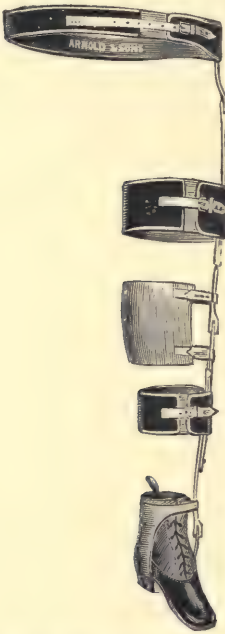
In some non-paralytic cases a toe-raising spring is not necessary; all that is required is a boot with two side-irons to keep the

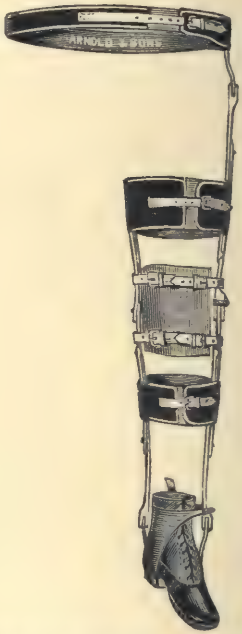

FIG. 189.—SIMPLE BOOT WITH LEG-IRONS, CALF-CIRCLET AND T-STRAP.

foot in position with the leg-bones, the weight of the body being sufficient to prevent a return of the equinus.

When the paralysis extends to the quadriceps extensor muscle of the thigh, the leg-irons should be carried above the knee to a thigh-circlet round the lower third of the thigh, and the outer iron should be further continued to the pelvis and there secured to a pelvic girdle. In those cases where the paralysis of the quadriceps extensor is complete, it is usually necessary to fix the knee rigidly in the position of extension. This can be done by putting a screw through the joint at the knee. In children who

in consequence of the paralysis have not walked, or have only got about on crutches, rigidly fixing the knee in extension is essential; later, should some power be regained in the quadriceps, the screw can be removed. For cases where the paralysis of the quadriceps is complete and electrical investigation holds out no hope of improvement, some contrivance is advisable to allow the knee, whilst held rigidly straight for progression, to be bent during





Figs. 190 and 191.—Walking Instruments for the Mechanical After-Treatment of Equinus of Paralytic Origin.

In Fig. 190 the leg-iron is continued to a pelvis-girdle. In Fig. 191 the inner and outer irons are carried above the knee, and the outer iron is further continued above the hip to a pelvis-girdle. At the ankle and hip free joints are placed. At the knee is a ring-catch.

sitting and in going up and down stairs. For this purpose there are several mechanical appliances. One of the most useful is the ring-catch (Fig. 192).

*The Ring-catch* consists of a square ring or collar which can be moved up and down the leg-iron, so as to fasten or release the

joint at the knee. This collar is made to work tightly by means of the small spring shown in the figure. When the ring or collar is drawn upwards, the joint is unlocked and the leg can be flexed. When the ring or collar is pushed down, the joint is fixed in the position of extension, the knee being thus held rigid. A front-stop in the joint prevents the leg-iron moving in the direction of extension beyond the vertical. The ring-catch is perhaps a little

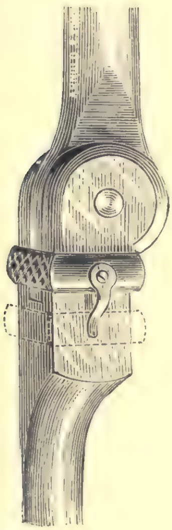


FIG. 192.—THE RING-CATCH.

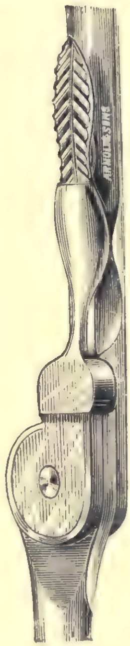


FIG. 193.—THE FLUTE-KEY CATCH.

troublesome to work, and the flute-key-catch is at times substituted for it. This contrivance (Fig. 193), as the name implies, somewhat resembles the key of a flute. When the handle is pressed inwards towards the leg-iron, the joint is released and the leg can be flexed.

In using either the ring-catch or the flute-key-catch, the leg must be placed in a straight line with the thigh for the contrivance to act. This may be accomplished by the patient placing his heel

on the ground, whilst in the sitting posture, and then pressing back the knee with the hand, till the leg and thigh iron are in the same straight line and the ring can be pushed home, or the key can fall into place. Or he must draw forward the leg with the hand, or have it drawn forward for him. To obviate the difficulties of using the ring-catch, one of the authors (Mr. Walsham) some years ago conceived the idea of making the muscles which run from the pelvis to the thigh do the work of the paralyzed

FIG. 194.—WALSHAM'S INSTRUMENT FOR OBTAINING A MOVABLE KNEE IN PARALYSIS OF THE EXTENSOR MUSCLES.

xtensors of the thigh. This idea was carried out for him by Messrs. Arnold, and the instrument is shown in Fig. 194. It consists of the ordinary walking instrument, as already described, to which are fitted two levers, so arranged and adjusted that when the body is straightened at the hip, as in rising from a chair, the levers, as the joint at the hip is straightened, act on the knee

and extend the leg. Thus, so long as the patient holds himself upright at the hip, that is, keeps his hip extended by the sound muscles, the levers hold the knee in the same rigidly extended state. Conversely, on bending the body forward, as in sitting down, or in going up or down stairs, the leg also becomes flexed at the knee, and so prevents the toes catching. This instrument is only of service when the muscles which move the hip are strong and well developed; it is of no use whatever when they have been involved in the paralysis.

(2) *Physiological After-Treatment* should always be employed for some months. It consists in manipulation and passive movements of the joints, exercise of the muscles acting on the joint, massage and electricity. These various methods have already been discussed under the head of Manipulative Treatment (p. 294). All that need be further said here is that this treatment should in paralytic cases be kept up for some months—indeed, roughly speaking, as long as any improvement is obtained. In the Electrical Department of the hospital, to which most of our orthopædic cases are referred for the electrical part of the treatment, Dr. Lewis Jones has had some excellent results even in what appeared at the outset of the treatment almost hopeless. But the current must be applied for many months and regularly to obtain much benefit. Some of the patients referred to him have been under treatment for upwards of a year, attending regularly once or twice a week. In some paralytic cases electrical treatment is hopeless, and should not be employed. Whilst the physiological after-treatment is being carried out, the patient will usually require some mechanical contrivance to hold the foot in the restored position and prevent it falling back into the deformed state (see Mechanical After-Treatment, p. 311).

Statistics of Talipes Equinus.—During ten years (1882-93), 326 cases of talipes equinus were treated in the Orthopædic Department of St. Bartholomew's Hospital. Of these 326 cases, 154 were males, 172 females. Both feet were affected in 42 cases, the right foot only in 118, the left only in 72.* The deformity was combined with varus in 120 cases, with cavus without varus

* The note is silent as to which foot was affected in 94 cases.

in 76 cases, with valgus in 11 cases, with clawed toes in 43 cases, with clawing of the great toe only in 9 cases, and with complete bending under of the toes in 3 cases. In 47 cases the deformity consisted merely of right-angled contraction of the tendo Achillis. All the muscles reacted to electrical stimulus in 10 cases. All the muscles were paralyzed in 1 case. The tibialis anticus was alone paralyzed in 3 cases; the peronei and extensor longus digitorum alone in 3 cases.

## CHAPTER VIII.

# TALIPES EQUINO-VARUS AND TALIPES EQUINO-VALGUS.

### Talipes Equino-Varus.

**Definition.**—This deformity may be looked upon as a variety of talipes equinus, that is, as equinus in which the natural inversion of the foot that always occurs in full plantar flexion is increased,

FIG. 195.—PARALYTIC EQUINO-VARUS IN A BOY OF SIX YEARS. (From a photograph taken by Mr. Griffiths in the Orthopædic Department, St. Bartholomew's Hospital.)

The paralysis was of five years' duration.

so that in addition to equinus there is more or less inversion or varus. Cases of true equinus, that is, equinus without any inversion, are, comparatively speaking, uncommon. For not only does the shape of the trochlear surface of the astragalus favour

some inversion and adduction during normal plantar flexion (see Chapter I., p. 20), but the arrangement of the ligaments and the disposition of the bones are such that during this movement abduction and eversion are actively opposed. Such a slight deviation inwards, however, as then occurs may be disregarded, and the deformity be still classed as equinus, the compound term being reserved for those cases in which the inversion is pronounced and forms a well-marked feature.

In equino-varus, the peronei as well as the anterior muscles

Fig. 196.—Paralytic Equino-Varus with Cavus and Clawed Condition of First Digit. (From a photograph of a patient in the Orthopædic Department of St. Bartholomew's Hospital by Mr. Clindening.)

The varus is more marked than appears in the photograph, as the leg is rotated outwards. When the tibialis anticus was divided, the ends were separated for at least two inches. When the extensor proprius hallucis was divided, the proximal end could not be felt on the dorsum—it was very tense before division. The position of the great toe was rectified after the tenotomy. Both tendons united quickly and firmly.

are generally affected, thus leaving the strong inverting action of the tibialis anticus and tibialis posticus unopposed.

**Description.**—In a well-marked case (Fig. 196) the heel is raised, and the anterior part of the foot is strongly inverted and adducted. The patient walks with the posterior part of the foot raised off the ground, on the heads of the outer metatarsal bones

FIG. 197.—PHOTOGRAPH OF A CAST OF A FOOT THE SUBJECT OF PARALYTIC TALIPES EQUINO-VARUS. (No. 94A, St. Bartholomew's Hospital Museum.)

FIG. 198.—PHOTOGRAPH OF AN ASTRAGALUS FROM A CASE OF PARALYTIC EQUINO-VARUS, SHOWING BUT LITTLE LATERAL DEVIATION OF THE NECK OF THE ASTRAGALUS.

in slight cases, and on the outer edge and outer part of the dorsum of the foot in the more severe (Fig. 197).

Since inversion and adduction are accompanied by a shortening

FIGS. 199 AND 200.—PHOTOGRAPHS OF A PARTIAL DISSECTION OF THE LEFT LEG AND FOOT, SHOWING EXTREME EQUINO-VARUS AS THE RESULT OF INFANTILE PARALYSIS. (No. 3219, St. Bartholomew's Hospital Museum.)

The muscles preserve their normal form, but are completely converted into fat, except the inner head of the gastrocnemius. The foot is immovably fixed in the position above seen.

The patient, aged seventeen years, suffered from infantile paralysis since three years of age.

of the antero-posterior diameter of the inner edge of the foot, a deepening of the plantar arch (*talipes cavus*) takes place almost

Fig. 201.—Photograph of a Specimen of Paralytic Talipes Equino-Varus in a Girl aged Sixteen (Front View). (No. 3515, St. Bartholomew's Hospital Museum.)

The limb had not been used for walking for seven years, but up to nine years of age the girl walked on the dorsum of the foot. The paralysis occurred at the age of four. The gastrocnemius and soleus are said to have been fatty, but there is a well-formed tendo Achillis. The extensor longus digitorum is very small and fatty, and the tendons are thin and attenuated. The extensor proprius hallucis is in good condition, as is also the tibialis anticus. The posterior muscles, especially the flexor longus digitorum, are in good condition. Only the tendon of the peroneus longus is present, and it is very small—much smaller than that of the peroneus brevis, which is well represented. The tibialis posticus is said to have been fatty, but not a particle of the muscle or tendon is left in the specimen.

universally in equino-varus (Fig. 196), and more rapidly than in simple equinus. The plantar fascia hence becomes contracted and tense, and the short muscles of the sole undergo to a greater or less extent adaptive shortening. A clawed condition of the great toe or of all the toes, as in simple equinus, is not uncommon,

FIG. 202.—PHOTOGRAPH OF A SPECIMEN OF PARALYTIC TALIPES EQUINO-VARUS IN A GIRL AGED SIXTEEN (BACK VIEW). (No. 3515, St. Bartholomew's Hospital Museum.)

and probably admits of a similar explanation (see Equinus, p. 263).

### Pathological Anatomy of Talipes Equino-Varus.

**The Bones.**—On referring to the photographs of the dissected foot (Figs. 201, 202), it will be seen that the inward deviation occurs chiefly at the transverse tarsal and sub-astragaloid joints.

With this exception the anatomical relations of the bones are the same as in simple equinus.

**The Astragalus.**—The neck of the astragalus descends almost vertically, its head being twisted slightly outwards, as in inversion of the normal foot. There is not, as seen in Fig. 198, the inward deflection of the neck so characteristic of congenital varus.

**The Scaphoid** is drawn on to the inner surface of the head of the astragalus, leaving the outer part of the articular surface of that bone exposed (Fig. 201).

FIG. 203.—PHOTOGRAPH OF THE FOOT OF A GIRL WITH HYSTERICAL TALIPES EQUINO-VARUS.

When the patient first came under notice the foot was kept in a position of marked equino-varus, and she walked partly on the dorsum of her foot. She could not be induced to straighten the foot, but by strong and continuous manipulation the malposition was gradually overcome, hysterical ankle-clonus supervening and rendering reduction easier, as she then lost control of her muscles. She was also subject to hystero-epileptic fits. The photograph was taken after a fortnight's treatment, when the tendency of the patient to keep the foot in the position of equino-varus had been somewhat overcome. For one week the foot had been fixed in the normal position in plaster of Paris.

**The Cuboid** is drawn slightly downwards and inwards, leaving the upper part of the articular surface of the anterior end of the os calcis free (Fig. 175).

**The Cuneiform and Metatarsal Bones,** with the **phalanges**, all maintain their relations to the bones with which they articulate, continuing the inward deviation.

**The Muscles.**—In addition to the changes in the muscles described in equinus, the anterior, and occasionally the posterior, tibial muscles will be found strongly contracted (Fig. 201).

### Etiology of Talipes Equino-Varus.

Infantile paralysis, even more universally than in the case of simple equinus, is the cause of this deformity; but the other conditions mentioned at p. 267 as causes of simple equinus are also said to be occasionally the cause of equino-varus. Hysteria, however, is the only condition other than infantile paralysis that

Fig. 204.—Photograph of a Plaster Cast of the Legs of a Girl with Hysterical Equino-Varus. (St. Bartholomew's Hospital Museum.)

we have met with in our clinique as occasioning the deformity (Figs. 203, 204).

**Diagnosis.** — Paralytic talipes equino-varus may have to be diagnosed from congenital varus (congenital equino-varus of some authors). As a rule, there is no difficulty. In congenital varus of long-standing, however, the muscles may become wasted from want of use, thus simulating paralytic equino-varus, and a history of the deformity being present at birth may not be obtainable. In such cases the general rounded appearance of the foot

in paralytic equino-varus (Fig. 206), and the absence of the irregularities on the dorsum of the foot (Fig. 195), and of the transverse and longitudinal furrows on the sole, so characteristic of congenital varus (compare Figs. 207 and 44, pp. 330 and 57), will aid in the diagnosis.

Hysterical equino-varus may be diagnosed from the paralytic form in that the deformity can be overcome by forcible manipulation, hysterical ankle-clonus supervening and rendering reduction easier. The absence of wasting of the limb, electrical

FIG. 205.—PHOTOGRAPH OF TWO CASTS OF TALIPES EQUINO-VARUS FROM INFANTILE PARALYSIS BEFORE AND AFTER TREATMENT BY TENOTOMY. (St. Bartholomew's Hospital Museum.)

tests, and the presence of other signs of hysteria will generally further reveal the nature of the case.

**Treatment.**—The treatment is similar to that of equinus. The plantar fascia and tendo Achillis will generally require division, and in paralytic cases an instrument like that employed in simple equinus will have to be worn to keep the foot in the restored position. The instrument must be somewhat modified, however, so as to correct the tendency to inversion of the foot. In slight cases, setting the outer iron at its insertion into the heel of the

FIG. 206.—PHOTOGRAPH OF A PLASTER CAST FROM A CASE OF TALIPES EQUINO-VARUS, FOLLOWING INFANTILE PARALYSIS, IN A PATIENT FORTY-FIVE YEARS OF AGE (FROM ABOVE).

The paralysis came on during infancy, and the patient began to walk on her knees at twelve years, and never walked or stood on her feet after seventeen years. The cast was taken in the best position the foot could be made to assume. When the patient endeavoured to stand she rested on the dorsum of the foot. After syndesmotomy of the astragalo-scaphoid capsule and tenotomy of tendo Achillis the foot was brought quite straight.

FIG. 207.—PHOTOGRAPH OF A CAST OF PARALYTIC TALIPES EQUINO-VARUS, FROM THE SAME PATIENT AS THE PRECEDING ILLUSTRATION (FROM BELOW).

The longitudinal and transverse furrows in the sole, so characteristic of the congenital form of talipes varus (equino-varus), are absent.

boot further forward than the inner iron may suffice, but in severe cases, where the knee-joints are loose and the paralysis is extensive, affecting some of the thigh, and perhaps pelvo-femoral muscles, as well as those of the leg, the inversion must be combated in addition by some of the methods of fixing the thigh-iron to the pelvis-girdle described under varus at p. 234.

In severe cases, as that from which Fig. 206 was taken, where the foot cannot be restored by tenotomy and fasciotomy, syndesmotomy of the astragalo-scaphoid capsule, or, in still more inveterate cases, some one or other of the operations on the tarsal bones described under congenital varus, may be necessary to restore the shape of the foot, and enable the patient to walk with the sole flat on the ground.

Massage and galvanism will also be useful after the division of the contracted tendons and fascia in many cases, and should be persevered in for long periods if they are to do any good in the paralytic forms.

## Talipes Equino-Valgus.

**Definition.**—Talipes equino-valgus may be defined as a combination of equinus with valgus; that is, of contraction of the tendo Achillis with eversion and abduction of the anterior part of the foot.

Talipes equino-valgus is much less common than talipes equino-varus, and is generally of paralytic origin. By some authors, notably Mr. Adams, equino-valgus is regarded as a modification of talipes valgus, rather than of talipes equinus. In some cases, no doubt, the valgus position of the foot is the most marked feature, the equinus being reduced to a right-angled contraction of the tendo Achillis; and it is probable that such cases have led these authors to regard the condition as a modification of valgus. In other instances (Fig. 208), however, as in simple equinus, the contraction of the tendo Achillis is pronounced, and the heel markedly raised from the ground (Fig. 209). Such, therefore, could hardly be looked upon as modifications of valgus.

In both classes a division of the tendo Achillis is necessary, as in ordinary equinus. It seems, therefore, a pity to separate them.

**Description.**—Equino-valgus occurs chiefly in two sets of cases: (1) those in which the equinus is marked and the muscles of the leg generally are much affected (Figs. 208, 209); and (2) those in which there is no more equinus than right-angled contraction of the tendo Achillis, with some weakness of the tibial muscles. In the first class of cases the heel is raised, whilst the anterior part of the foot is abducted and everted at the medio-tarsal and subastra-

Fig. 208.—Photograph of Talipes Equino-Valgus in an Adult, following upon Infantile Paralysis.

There is much wasting of the anterior muscles of the leg and foot, and of the tibialis posticus in addition.

galoid joints. The sole is flat, or it may be convex, and the patient walks on the anterior part of the inner border of the foot, which is more or less convex; whilst the external border is raised from the ground.

In some instances, as in Fig. 209, the toes are doubled under in

the plantar-flexed position, as in equinus. The tendo Achillis is tense, and the foot is elongated in consequence of the loss of its arch and as the result of its abducted and everted position.

In the second class of cases, in which there is mere right-angled contraction of the tendo Achillis, the heel does not appear raised, and the foot, in consequence of the abduction and eversion, presents the appearance of valgus; but on attempts at dorsal flexion, the foot cannot be forced beyond a right angle with the leg. This class of case is described by Mr. Adams as talipes valgus with contraction of the tendo Achillis. The congenital form may be mistaken, as he points out, for congenital calcaneo-valgus, since, as he says, the arch of the foot is really reversed by the anterior portion of the foot being bent upwards from the transverse tarsal joint, at the same time that the tuberosity of the os calcis is elevated by the contraction of the tendo Achillis. 'The large mass of fat which exists in the situation of the heel in infants so completely conceals the os calcis as to render it difficult to ascertain its exact position.'

**Symptoms.**—Talipes equino-valgus gives rise to considerable pain and difficulty in walking, and is often accompanied by shortening of the limb, and much wasting in paralytic cases. There is also present in paralytic cases the bluish-red and congested appearance and cold condition of the limb characteristic of infantile paralysis.

**Etiology.**—The affection may be congenital or acquired. The congenital, like other congenital deformities of the foot, has been, and still is, the subject of dispute. It is considered under the general question of congenital varus. The acquired forms are nearly always the result of infantile paralysis. In the slightest degrees the paralysis may be limited to a slight weakening of the tibials and anterior muscles. In the more severe, extensive paralysis of the muscles, not only of the leg, but of the thigh and pelvo-femoral muscles, may be present, whilst some power may remain in the abducto-evertor muscles, thus causing the valgus. The calf muscles, at the same time, having to some extent escaped, the foot is fixed in the equinus position by the contraction of the tendo Achillis.

### Pathological Anatomy of Equino-Valgus.

**The Bones.**—The **Astragalus** is, to a greater or less extent, tilted forwards out of the socket formed for it by the bones of the leg, as in simple equinus; whilst the tuberosity of the os calcis is more or less raised and rotated, so that its inner surface looks downwards and inwards, and its anterior end somewhat outwards as well as forwards.

**The Scaphoid and Cuboid** undergo similar alterations to those described in talipes valgus. Thus, the inner border or tuberosity of the scaphoid is depressed, whilst the outer extremity is

FIG. 209.—PHOTOGRAPH OF TALIPES EQUINO-VALGUS FROM THE SAME PATIENT AS FIG. 208.

raised. The outer part of the cuboid is raised to a less extent. In consequence of the excessive abduction and eversion of the foot, the natural arch is lost and the sole becomes flat, or even convex, when there is much drawing upwards of the anterior part of the foot by the dorsal flexors. The bones themselves are very little, if at all, altered in shape.

**The Ligaments** become elongated on the anterior and inner border of the foot, and contracted on the outer border and behind the ankle. For a more detailed account, the reader is referred

to the chapters on the uncomplicated forms of equinus and valgus.

**The Muscles** in congenital cases are, as a rule, unaffected in structure. In the paralytic cases the anterior and the adductor muscles, namely, the tibials, are more or less involved, whilst the peronei and the calf muscles are contracted and shortened. As in simple paralytic valgus, however, the tibialis anticus may be the only adductor involved. The valgus position is then usually less than when both the tibialis anticus and posticus are paralyzed.

In rare instances the fibula may be absent, or its lower end may be deficient or absent. In these cases the eversion may be extreme.

### Treatment of Equino-Valgus.

In *congenital* equino-valgus, division of the tendo Achillis is generally necessary, and the earlier it is done the better the result. Subsequently the foot should be placed in plaster of Paris with the equinus and valgus position corrected. The plaster may be removed weekly, and the leg and foot well manipulated before each reapplication. In this way we have generally been able to cure the deformity before the period at which the child begins to walk. If, however, at this period, any tendency to valgus should remain, it may be corrected by exercises of the foot (see 'Valgus'), instruction in the proper way of walking, and the use, if necessary, of a valgus boot and iron. Should any right-angled contraction remain in consequence of the equinus position not having been properly overcome, the tendo Achillis may be redivided, and correction secured by plaster of Paris.

*In paralytic cases* the tendo Achillis, and sometimes the peronei, will require division, the foot being subsequently corrected by plaster of Paris, and then prevented from relapsing into the deformed position by means of a suitable instrument. The apparatus we have usually employed has consisted of a boot with outside leg-iron, or double leg-irons if the valgus deformity is extreme. A single T-strap attached to the inner side of the foot, and buckled over the outside iron, keeps the foot in place. Where the paralysis of the leg muscles is extensive, a double

T-strap, *i.e.*, one on the inner side and one on the outer side, buckled respectively over the outer and inner leg-iron, may be necessary to keep the foot in good position. A toe-raising spring, as in simple equinus, will tend to prevent a recontraction of the tendo Achillis. The eversion of the foot may be overcome by setting the inner iron at its insertion into the boot further forward than the outer, or, if this is not sufficient, by carrying the outer iron above the hip-joint, and fixing it there to a pelvis-girdle. The method of inverting or everting from the pelvis-girdle is discussed at p. 230. If there is shortening of the limb, the sole of the boot should be proportionately thickened.

Electricity and massage should be employed, as in other paralytic cases.

When the fibula is absent, or its lower end deficient, we have not found tenotomy of much avail. After division of the tendo Achillis and peronei, the foot could still not be inverted sufficiently for the sole to look towards the ground. The bones appeared to be fixed in the deformed position by locking against the internal malleolus. In such a case Mr. Walsham recently succeeded in restoring the foot to its normal position by removing a wedge-shaped piece of bone from the internal malleolus without opening the ankle-joint.

Where the foot can be rectified it must be held in the restored position by the use of a boot with double leg-irons and a valgus T-strap.

# CHAPTER IX.

## TALIPES CALCANEUS.

**Synonyms.**—Calcaneous club-foot ; Pes calcaneus ; Piedbot calcanéen ; Piedbot talus ; der Hakenfuss ; Piede calcaneo ; Piede ad uncino.

**Definition.**—Talipes calcaneus is a condition in which the heel is abnormally depressed, whilst the anterior part of the foot is either in a position of varying degrees of dorsal flexion or is bent downwards at the transverse tarsal joint so as to render the sole unnaturally concave.

**Varieties.**—Talipes calcaneus may be divided into the congenital and the acquired. The latter is the more common. During ten years there have presented themselves in the Orthopædic Department of St. Bartholomew's Hospital thirty-three cases of acquired calcaneus to twenty-four of the congenital variety. Hoffa,* out of nine cases of calcaneus that came under his notice, met with seven acquired and two congenital.

### Congenital Talipes Calcaneus.

**Description.**—The congenital affection is more commonly met with in a slight form, rarely in a severe degree. In a well-marked case the foot is dorsal-flexed at the ankle-joint, and held rigidly in this position by the anterior muscles and ligaments, which are felt contracted when an attempt is made to plantar-flex the foot. As a consequence of this dorsal flexion, the heel is unnaturally depressed, and the tendo Achillis stretched and elongated.

The foot, in brief, is held in the position in which it can be naturally placed by dorsal flexion at the ankle-joint. The sole is usually said to look outwards, the foot, in addition to the dorsal

* Hoffa, 'Lehrbuch der Orthopædische Chirurgie,' p. 702.

flexion, being externally rotated on its antero-posterior axis (talipes calcaneo-valgus). In our experience, however, the sole more often, especially in slight cases, looks inwards, a point which will be discussed later. Well-marked cases, such as the above-described, are rare. An infant holds its foot when at rest in a slight equino-varus position. Any departure from this position in the direction of dorsal flexion may be considered to be an incipient calcaneus. All degrees of the deformity, from such a mere tendency towards calcaneus up to the most severe, in which the dorsum of the foot is closely applied to the front of the leg, may be met with.

By some authors (Rédard, Reeves) these various phases of the deformity are grouped under three degrees. In the *first degree*, the foot is merely held at a right angle to the leg, and cannot beyond this be plantar-flexed. In the *second degree*, the foot is held at an acute angle with the leg. In the *third degree*, the back of the foot is applied to the front of the leg.

In slight cases, which are described by some writers as congenital talipes valgus or as calcaneo-valgus, nothing more may be apparent than that the heel is unusually prominent and somewhat depressed, and that the foot is held in a position of very slight dorsal flexion, or cannot be plantar-flexed beyond a right angle; whilst the elongated condition of the tendo Achillis allows the dorsum of the foot to be placed upon, or nearly upon, the leg. In such cases, as in the more severe, there is nearly always some rotation of the whole foot on its antero-posterior mesial axis. This rotation, as before mentioned, is usually said to take an outward direction. In most of the cases we have observed, however, the sole looked more inwards than normally. We do not agree, therefore, with the statement so commonly made, that the deformity is generally a calcaneo-valgus.

Mr. Adams* gives two illustrations of congenital calcaneus, in both of which the soles look markedly inwards, though he says that in his opinion eversion is the more frequent condition. Parker gives three representations of calcaneus; in two of them† the soles look distinctly inwards, though both are termed by him calcaneo-valgus. On page 55 of his book, however, he gives an

* Adams on 'Club-foot.'
† Parker, 'Club-foot,' Figs. 14 and 29.

illustration of calcaneus with eversion. Little* gives an illustration of a very severe case with marked eversion. Hoffa,† Duchenne,‡ Reeves,§ Martin,|| Holmes Coote¶ and Larabrie** all give illustrations of severe cases with inversion. The two illustrations (Figs. 210, 217) of cases from the Orthopædic Department at St. Bartholomew's both show inversion. If, then, eversion is the more common condition, it is somewhat curious that, out of twelve illustrations of published cases (the two from St. Bartholomew's being omitted), in ten the sole looks more inwards than normal, and in only two more outwards.

In nine slight and medium cases in which this point has been especially investigated at St. Bartholomew's, seven have presented inversion and only two eversion. So far as we can gather, then, from our own cases, and from those in which illustrations have been published by others, inversion seems to be the more common condition, and not eversion, as generally stated in the text-books. Although the sole may look inwards, still, the foot is, as a rule, quite flat, and the inner edge is more pronounced than normal, or even in some cases convex, especially in the region of the mediotarsal joint. Here we not infrequently meet with a distinct prominence due to the projecting scaphoid. This condition of the inner edge of the foot may have given rise to the generally accepted dictum that valgus is the common, if not universal, accompaniment of congenital calcaneus. But the inner edge is on a higher level than the outer, and although the scaphoid and astragalus are more prominent, they are elevated, and not depressed, as in valgus.

To continue the description of the deformity. The sole presents posteriorly in some cases a distinct bulging, due to the downwardly displaced os calcis. The position of the toes varies. In most of our severe cases, and in most of the illustrations of the cases of others, plantar flexion of the toes at the metatarso-phalangeal joints is present, and seems to be the common condition. Sometimes, however, as in Fig. 210 and in several of the illustrations

* Little, 'On Deformities.'
† Hoffa, 'Lehrbuch der Orthopædische Chirurgie.'
‡ Duchenne, 'Physiology of Movement.'
§ Reeves' 'Practical Orthopædics.'
¶ Holmes Coote, *Lancet*, Jan. and Feb., 1861.
|| Parker on 'Club-foot,' Fig. 16.
** Larabrie, *Rev. d'Orthopédie*, Sept., 1893.

we have referred to, the toes are fully extended. Besides the depression of the heel and dorsal flexion of the foot, there may be noted in slight cases a marked absence of tonicity about the whole foot. Most infants' feet exhibit an absence of tone, but the foot of one with a slight calcaneus will be found more flaccid still. In advanced cases, on the contrary, the foot is rigidly held in a condition of dorsal flexion by the strongly contracted anterior tendons, which resist all attempts at reduction, though a slight

FIG. 210.—PHOTOGRAPH OF A CASE OF CONGENITAL CALCANEUS IN A BABY OF TWO WEEKS OLD. (From a patient in the Orthopædic Department, St. Bartholomew's Hospital.)

The child was very small and wasted; the skin over the foot is generally loose, and even wrinkled on the sole. The right foot is only slightly deformed; the left foot is more markedly so, and in addition to the calcaneus position, there is a well-marked convexity on the inner border, due to the prominence of the scaphoid and head of the astragalus. In both feet the soles are inverted; the prominence on the inner edge of the left side renders this less evident in the photograph. The toes are not flexed. There is no tenseness of the anterior muscles, and the feet are easily restored upon manipulation to the natural shape, but cannot be plantar-flexed beyond a right angle with the leg.

increase of the deformity may be obtained by pressing the foot upwards.

A sort of spurious heel is often met with above the protuberance of the os calcis. It is apparently formed of the soft parts normally covering the bone not having followed the os calcis in its displacement downwards.

**Etiology of Congenital Talipes Calcaneus.**

The etiology of congenital calcaneus, as of other congenital malformations of the feet, is still obscure, and has long been a subject of discussion. As in other congenital forms of club-foot, four chief theories have been advanced to account for it: (1) The dynamic or musculo-nervous, in which it is maintained that the deformity is due to a spastic contraction of the anterior muscles of the leg, consequent upon some lesion of the nerve-centres; (2) the mechanical, which seeks to explain the deformity on mechanical grounds; (3) the arrest of development theory, which assumes an absence or retardation in the normal rotation inwards of the leg in utero; and (4) the germ theory, in which the malformation is ascribed to defect in the germ at the earliest period of development, as evidenced by the absence of a bone, as, for example, the fibula.

The last of these theories only applies to those rare cases of calcaneus, or, more correctly speaking, calcaneo-valgus, in which there is evident skeletal defect, such as absence of the fibula or of one or more of the tarsal bones, or deficiency of the toes; but as these cases* do not fall under our definition of congenital calcaneus, this theory may be dismissed.

Of the remaining theories, *the dynamic or musculo-nervous* has, perhaps, hitherto received the most support from surgeons in this country. Mr. Adams adopts it for severe cases in which there is rigid contraction of the anterior muscles, with extreme dorsal flexion of the foot, but admits that the slighter cases of congenital calcaneus, with very little muscular rigidity, may possibly be due to mechanical causes, such as position or pressure *in utero*. Mr. Brodhurst, in his work on club-foot, published in 1856, strongly advocates the dynamic theory. He says:† 'In conclusion, it may be summed up in few words, that congenital distortions depend on irritation of the cerebro-spinal system, or on inflammation or disturbance of part of that system.' In his more recent book, however, he has changed his opinion, and now admits that 'it is probable that calcaneus is occasioned by pressure *in utero*.'

* These cases are described under deformities of the toes.

† Brodhurst, 'Club-foot,' 1856, p. 58; *ibid.*, 1893, pp. 11, 12.

Mr. Little, also a supporter of the nervo-muscular theory as one of the principal causes of club-foot, is, however, convinced that calcaneus may be produced by some kind of pressure *in utero*. In addition to the arguments that have been used against the dynamic theory in discussing varus, there is a further one in calcaneus, that if the deformity is due to spastic contraction of the anterior muscles, the weaker muscles on the front of the leg must be assumed to overcome the stronger muscles of the calf; but, further, in cases of slight calcaneus there is nearly always an absence of any evidence of muscular contraction, and for such the dynamic theory must be abandoned; and if it does not hold for slight cases, it is surely simpler to look upon the severe as the result of a similar cause, and to explain the contraction of the anterior muscles which exist in them as due to pathological shortening in adaptation to position—a condition which all admit undoubtedly occurs after birth.

Again, if we attempt to explain the plantar flexion of the toes which is often found in severe cases as due to a similar spastic contraction depending upon nervous change, we are led to ask why the flexors, if impelled to contract by nerve irritation, do not overcome their weaker opponents on the dorsum. But if we look upon the contraction of the common flexor as consecutive to the contraction of its dorsal opponents, the theory of physiological shortening still holds good, and offers a satisfactory explanation why the foot is not in a position of plantar flexion.

*The Mechanical Theory.*—This theory has perhaps received the most support from recent writers. Even the upholders of the dynamic theory of club-foot in general admit that calcaneus may at times be due to mechanical causes; some, indeed, whilst still advocating the dynamic theory for other forms of congenital deformity, adopt the mechanical for this.

The arguments that have been used in support of the mechanical theory of the production of club-foot in general also apply to calcaneus. They have already been discussed at length under varus (see p. 70), and need not be repeated here. With regard to calcaneus, the influence of position in its production is very clearly brought out by Mr. R. W. Parker. In referring to those cases of calcaneus so, comparatively speaking, common in breech presentations, in which the thighs are flexed on the abdomen, the

legs are fully extended on the thighs, and the feet dorsal-flexed, so that they are pressed against the front of the tibia, he says: 'That this position is not a passing one, or one assumed by the fœtus at the time of parturition in adaptation to the requirement of the process, is plain from specimens showing this position some time before the full term. In Guy's Hospital Museum there are two fœtuses—one at seven months, within its membranes—exhibiting this position. A third specimen may be seen in the Museum of the Royal College of Surgeons, No. 3646A.' He further relates a case of talipes calcaneus in an infant whose mother suffered during gestation from a large tumour of the uterus; the right foot was doubled back on the leg, clearly in consequence of being pressed against the left side of the neck, on which there was a depression, the head being inclined to the right side. He goes on to show how abnormal positions of the limb will lead to locking of the foot or feet in the calcaneus position. Such cases are described and figured by Martin,* Volkmann,† and others. In one of Martin's cases the legs were extended, the feet flexed, the right foot everted, with the sole indenting the corresponding cheek—the heel pressing into the orbit, and causing atrophy of the globe. In one of Volkmann's cases the foot on one side is held in the position of calcaneo-valgus by the pressure of the opposite foot, which is itself in a position of varus.

It is interesting to note, says Mr. Parker, that Martin's case was one of extra-uterine fœtation; though the uterus, therefore, cannot be invoked as a cause of the deformity, it is none the less clear that environment has brought it about.

The same author figures a further example of double calcaneus in a case of extra-uterine pregnancy, where, in addition to the abnormal 'position of the feet, there were many other evidences of the mechanical action of environment on this fœtus.'‡

Under varus (p. 73) it was stated that in the earlier periods of pregnancy the feet are normally plantar-flexed and inverted—that is, are in the position of varus; whilst at a later stage they are dorsal-flexed and everted—that is, in the position of calcaneo-valgus. 'Should anything,' says Mr. Parker,§ 'prevent the feet

* Martin, 'Mémoire sur l'Etiologie du Pied-bot,' Paris, 1839.
† Pitha and Billroth's 'Handbuch,' vol. ii., chap. 48.
‡ Parker, 'Club-foot,' p. 40. § Parker, *op. cit.*, p. 35.

from assuming their positions at the proper time, or maintain them in any given position beyond the limit of time during which they should normally occupy such position, a talipes results. The severity of the deformity will be in direct ratio to the violence at work; the variety of the deformity will depend on the period when this violence first commences to act. The holders of the mechanical theory maintain that the cause of the foot being prevented from passing from the plantar-flexed and inverted position in the case of varus, into the dorsal-flexed and everted position, or being too long maintained in the latter position in the case of calcaneus, is to be ascribed to the fœtal environment, whilst

FIG. 211.—NORMAL DEVELOPMENTAL POSITION FAVOURING PRODUCTION OF CALCANEUS. (From Parker and Rédard.)

the advocates of the arrest of development theory, to be mentioned presently, hold, on the other hand, that the abnormal maintenance of the foot is the result of the failure of the process of evolution. The following figures show the normal positions of the fœtus that favour the production of calcaneus.

Fig. 211 is taken from Parker on 'Club-foot.' Fig. 212 represents a condition noted by Licetus and Vogt. Fig. 213 shows the position of the foot observed by Virchow and Bessel Hagen. Here the feet so press the one on the other that the

right is in a state of varus, the left in a state of calcaneus. The conditions in the environment of the fœtus, or in the fœtus itself, which it is believed may hold the foot in the normal position of dorsal flexion beyond the usual period, and so lead to shortening of the anterior ligaments and muscles, and thus produce calcaneus at birth, are as follows: 1. Disproportion

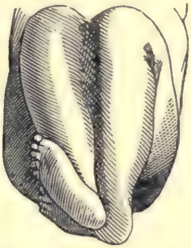


FIG. 212.—POSITION FAVOURING THE PRODUCTION OF CALCANEUS OBSERVED IN A FŒTUS BY LICETUS AND VOGT. (After Rédard.)

between the fœtus and the containing cavity, whether this be the uterus or a cyst in the case of extra-uterine pregnancy. 2. A deficiency of the liquor amnii. 3. Amniotic adhesions or

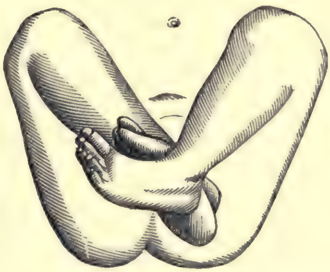


FIG. 213.—POSITION OF THE FŒTUS OBSERVED BY VIRCHOW AND BESSEL HAGEN. (After Rédard.)

amniotic bands. 4. Tumours of the uterus, whereby its normal shape and size are altered. 5. Accidental locking of the feet, as shown in Fig. 214. 6. Twin pregnancies, double monsters, hydrocephalus fœtus, and like conditions which it is thought may diminish the intra-uterine space. 7. Certain morbid con-

ditions of the fœtus itself, such as rickets, congenital paralysis, etc.—conditions, that is, that may diminish the resisting power of the fœtus, and so render slight pressure in the environment the more likely to take effect. 8. A combination of any of the above-mentioned states.

According to the *Arrest of Development Theory* the continuance of the foot in the calcaneus position in the later stages of gestation, as in the varus position in the earlier, is due to some want of power in the developmental process in the fœtus itself, quite independent of its environment. The supporters of this view, however, do not seem very clear as to the reason of this so-called arrest in the fœtal evolution.

### Pathological Anatomy of Congenital Talipes Calcaneus.

**The Bones.**—The alteration in the position and shape of the bones in congenital calcaneus is much simpler than in talipes

FIG. 214.—A FŒTUS SHOWING ACCIDENTAL LOCKING OF THE FEET. (From a specimen of a fœtus in St. Mary's Hospital Museum.) (After Parker.)
The feet are in a position of slight calcaneus.

varus. In talipes calcaneus, as in talipes equinus, the position of the bones is one in which they can be placed in the normal movements of the foot. The alteration in the shape of the bones is, except in severe cases, very slight, and even then almost entirely confined to the astragalus and os calcis. The foot, as a whole, is in a position of dorsal flexion, the posterior extremity of the os calcis being in consequence depressed. Or in very slight cases the foot may be merely held at a right angle to the leg, beyond which angle it cannot be plantar-flexed. In the slightest cases, therefore, there may be no alteration either in the position or shape of the bones, but merely some shortening

of the anterior muscles and anteriorly placed ligaments of the ankle-joint.

In the more severe cases, in addition to the shortening of the anterior muscles and ligaments, the posterior ligaments have been found elongated and the tendo Achillis stretched.

The following description of the changes in the bones, ligaments, and muscles that may occur in severe cases is based on a dissection in St. Bartholomew's Hospital Museum, and on specimens reported by Parker, Hoffa, Nicoladoni, Messner, and others.

**The Astragalus.**—At times, even in a well-marked case, the astragalus may present no recognisable deviation from the normal form. In a case described by Mr. Parker, the only alteration was the presence of a vertical ridge down the middle of the external malleolar or fibular facet, the anterior part alone of this facet corresponding with the malleolus in the fully-flexed position of the foot. In another case the trochlear surface of the astragalus was prolonged forwards on the upper surface of the neck of the bone, as far as the margin of the scaphoidal facet, whilst the internal malleolar facet was prolonged on the inner side of the neck nearly as far forwards as the limit of the margin of the scaphoidal surface.

The obliquity of the neck in both these cases was somewhat increased; in one it was 33°, in the other 39°. Both dissections were taken from young subjects, one a fœtus of eight months, the other an infant of seven and a half months.

In Nicoladoni's case, in which the patient was older (14 years),* the astragalus was pressed so far backwards as to give rise to a prominence at the back of the heel, and the whole bone was flatter and longer, the neck being especially elongated, and presenting a groove on its upper surface for the anterior margin of the lower end of the tibia, which was abnormally developed. In Messner's case,† that of a child of six weeks, similar changes were observed. The groove on the astragaloid neck was found covered with cartilage. The bone was so shifted on the os calcis (see Fig. 215) that the cartilage-covered head was almost on the same horizontal plane as the anterior cuboidal facet of the os

* Hoffa, 'Lehrbuch der orthopaedischen Chirurgie,' p. 704.
† Hoffa, *op. cit.*, p. 703.

calcis, instead of on a higher one, as in the normal condition of the parts.

The two inferior articular facets may so glide on the corresponding facets on the os calcis that the interosseus groove, instead of being oblique from above downwards and within outwards, as in the normal bone, is directed transversely. In a case described by Lannelongue, the astragalus was displaced towards the posterior part of the os calcis. In our specimen the astragalus has its head projecting very prominently on the inner side of the foot, but in one described by Kustner the long axis looked obliquely upwards and outwards.

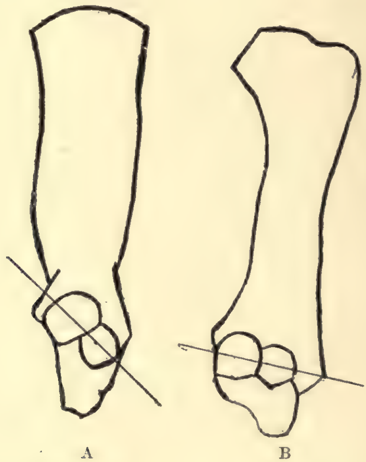



FIG. 215.—TO SHOW THE RELATIVE POSITION OF THE ASTRAGALUS AND OS CALCIS IN (A) NORMAL, (B) CALCANEUS, FOOT. (After Hoffa.)

**The Os Calcis.**—In slight, and even moderately severe, cases in the infant, except the depression of the posterior end of the os calcis, consequent upon the dorsal flexion at the ankle-joint, no abnormality of the bone may exist. In severe cases in older subjects the os calcis has been found almost vertical with the bones of the leg, the posterior end being directed to the ground. The anterior end is sometimes excessively developed, and the cuboidal facet, instead of being on a lower level than the anterior

surface of the head of the astragalus, has been found almost in the same horizontal plane with it (see Fig. 215).

In Lannelongue's case the anterior end was defective, and in Kustner's a deep notch existed in this situation as the result of pressure of the astragalus.

The sustentaculum tali may be very small, and the anterior upper or front astragaloid facet may look inwards instead of upwards.

**The Scaphoid** is always found, according to Hoffa, closely approximated to the internal malleolus.

**The Remaining Bones of the Foot.**—The cuboid and the cuneiform and metatarsal bones present nothing abnormal. In our

Fig. 216.—Congenital Calcaneus. (After Hoffa.)
The anterior muscles are contracted.

specimen all the toes are flexed upon themselves at the metatarso-phalangeal joints.

**The Ligaments.**—The anterior ligament of the ankle-joint appears to be always shortened. In severe cases the anterior fasciculi of the internal and external lateral ligaments share in the shortening. The posterior ligaments, on the other hand, are stretched and lengthened.

**The Muscles.**—In the infant, beyond a shortening of the anterior muscles and a general want of muscular tone, no recognisable abnormality in the muscles has been discovered. In older patients,

where the deformity has existed for some years, the calf muscles have been found atrophied. This is markedly the case in the St. Bartholomew's specimen, the muscles here being so wasted that the back of the leg is flattened or almost concave instead of presenting the convex fleshy swelling normally produced by the bellies of these muscles.

All the muscles of the limb to a less extent have been found wasted, but neither these nor the gastrocnemius nor soleus have presented any deviation, beyond the wasting, from their healthy structure. When examined microscopically, they have been found

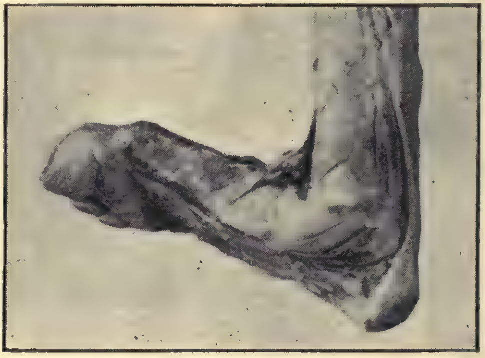


Fig. 217.—Photograph of a Specimen (partially dissected) of Congenital Calcaneus, showing Slight Inversion of the Foot and Plantar Flexion of the Toes, especially of the Great Toe. (No. 3509, St. Bartholomew's Hospital Museum.)

**The tendo Achillis is of a fair size, but the gastrocnemius is not well developed. Upon attempting reduction, the tibialis anticus becomes very tense, and the extensor proprius hallucis also, but to a less extent.**

composed of healthy muscle tissue. The tendo Achillis, in consequence of the dorsal flexion, has appeared deeply placed in some cases, so that its edges could not be felt. In others it has been pressed outwards or backwards by the backwardly displaced astragalus. In our specimen the tendo Achillis, notwithstanding the atrophy of the calf muscles, is well developed and holds about its normal situation as regards the mesial axis of the limb. The peronei have been found displaced from their groove and running in front of the external malleolus. In other specimens they have

been found in their normal situation, of large size, and well developed.

*Description of a Specimen of Congenital Talipes Calcaneus, from a Subject aged Four Weeks, dissected by Mr. Kent Hughes for the St. Bartholomew's Hospital Museum.*

The child was the subject of spina bifida and of congenital varus of the left foot and calcaneus of the right. The right foot and leg are small and wasted. The foot is moderately dorsal-flexed, and when at rest forms an acute angle with the leg; in the fullest plantar flexion it cannot be brought to a right angle with the leg. The head of the first metatarsal bone is raised above the level of the inferior border of the heel to the extent of a little over an inch and a quarter. The foot is distinctly inverted, its inner edge being raised fully half an inch above the level of the outer edge. The line of the first metatarsal bone continued backwards falls on the outer surface of the tibia. The toes are all strongly plantar-flexed at the metatarso-phalangeal joints, a condition, in our experience, usually met with in cases of congenital calcaneus. The sole is flat, and looks distinctly forwards and inwards. The scaphoid and head of the astragalus are prominent on the inner border of the foot. The prominence of the posterior part of the os calcis is well marked, and encroaches somewhat on the plantar surface.

All the muscles exhibit their normal structure, but are small. The gastrocnemius and soleus are ill developed, and are so small that the prominence of the calf is flattened, the leg posteriorly being almost concave rather than convex. The tendo Achillis is of fair size. On attempting to plantar-flex the foot, all the anterior tendons—but especially the tibialis anticus and the extensor proprius hallucis—become very tense. The peronei are large and well developed. The ligaments and bones were not dissected on account of a desire to retain the muscles and tendons undisturbed.

## Diagnosis and Prognosis.

**Diagnosis.**—Medium and severe cases of congenital calcaneus can hardly, having been once seen, be mistaken for any other deformity. Slight cases with eversion of the foot might be confounded with talipes valgus. In the latter affection, however, the heel is raised, and the inner border of the foot depressed. In

slight cases of calcaneus, on the other hand, the heel is depressed, and, although the sole of the foot may be flattened and look outwards, the inner edge is really raised and higher than the outer, the scaphoid being approximated to the internal malleolus, and not at a greater distance from the malleolus, as it usually is in valgus. In calcaneus, moreover, the foot, if not dorsal-flexed, at least cannot be plantar-flexed beyond the right angle, but can be placed with its dorsum on the front of the leg. In valgus, though plantar flexion may be limited, the foot can be plantar-flexed beyond the right angle, but cannot be dorsal-flexed so as to place it in contact, or nearly in contact, with the leg.

**Prognosis.**—The prognosis in congenital calcaneus is very favourable. In slight cases the action of the more powerful calf muscles and the force of gravity are in themselves almost sufficient to overcome the less powerful anterior muscles and shortened anterior ligaments; and when these forces are combined with manipulation of the foot in the direction of plantar flexion, the deformity usually yields in a few months. In severe cases division of the anterior tendons, and even ligaments, may be necessary; but after the foot has been once restored to its normal shape there is no tendency, as in varus, towards a relapse. The bones have not undergone the profound alteration in shape and position that they have in the latter affection, and the pull of the stronger muscles and the effect of the weight of the body in walking tend to the correction of the deformity instead of increasing it as in varus.

**Complications of Congenital Calcaneus.**—1. *Congenital varus* of the opposite foot is of frequent occurrence. Six out of the twenty-four cases of talipes calcaneus that presented themselves in the Orthopædic Department during ten years had varus of the opposite foot.

2. *Various Deformities attributable to Defects of Development*, such as spina bifida, anencephalus, hydrocephalus, cleft palate, imperforate anus, are met with in calcaneus as in other congenital deformities of the foot.

3. *Genu retrorsum*, or *genu recurvatum*—a condition in which the leg is hyperextended upon the thigh at the knee-joint—is, comparatively speaking, a common complication of congenital talipes calcaneus. An illustration of this condition taken from Volkmann

is appended. We have seen two similar cases, and a cast of one of them is contained in our museum. A slight degree of this condition of the knee-joint is not very uncommon at birth, but soon yields to manipulation. In the severe forms that have come under our notice, the leg has been either rigidly held in the extended position, or hyperextended, as shown in the woodcut (Fig. 218). The patella is small, and only felt with difficulty at the bottom of the sulcus formed by the wrinkled folds of skin that exist at the angle of hyperextension. On attempting to flex the leg it is found either to be rigidly held in the hyperextended position, or to yield slightly on attempts at flexion. The condition depends, on shortening not only of the muscles,

FIG. 218.—TALIPES CALCANEUS WITH GENU RECURVATUM. (After Volkmann.)

but also of the ligaments, and on an alteration in the joint surfaces of the femur and tibia. On division of the rectus muscle it has been found that the leg cannot be flexed until the capsule has been divided in front of the lateral ligaments (Shattock). Some limitation of extension at the hip-joint is also frequently present. The deformity is generally symmetrical. Long-continued systematic manipulation in the direction of flexion at the knee, combined with the application of mechanical flexion by the aid of plaster of Paris, succeeded in producing a fairly useful limb in our cases.

4. *Absence of Bones.*—Complete or partial absence of the fibula, less often of the tibia, or of the tarsal bones and bones of the toes,

is not unfrequently met with in association with talipes calcaneus, especially the valgus variety. These conditions are referred to under 'Deficiencies of the Toes.'

### Treatment of Congenital Talipes Calcaneus.

The treatment of congenital talipes calcaneus is, as a rule, most satisfactory. The deformity readily yields in all but the severest cases to very simple surgical procedures. These methods may be considered under the heads of manipulative, mechanical, and operative treatment.

**Manipulative Treatment.** — In those comparatively common and slight cases in which the foot cannot be plantar-flexed beyond a right angle with the leg, little more than manipulation is required to overcome the contracted muscles and ligaments. It will often be quite sufficient merely to instruct the mother or nurse to repeatedly draw the infant's foot downwards towards the position of plantar flexion, and at the same time well rub the leg, especially the calf muscles. In more severe cases the use of some mechanical means, in addition to the manipulation, will generally be required to overcome the dorsal flexion. The mother or nurse with one hand should hold the infant's leg, and, with the other holding the foot, should gently force the foot as far as it will go towards the position of plantar flexion without making the child cry, and hold it in this position, keeping up the pressure for five to ten minutes at a time. The foot should then be abducted and adducted, inverted and everted, and finally circumducted. These latter movements are more especially indicated where there is any appreciable rigidity at the ankle and sub-astragaloid joints. If this method is systematically carried out, slight cases should be practically cured in from a month to two or three months. When once cured, there is not the tendency to relapse that there is in congenital varus. But massage of the limb may be advantageously continued for some months longer, to promote the nutrition of the calf-muscles.

**Mechanical Treatment.**—This will be considered under the heads of bandaging and splints.

*Bandaging.*—In conjunction with manipulation aud massage, a well-applied domett bandage in the intervals and during the

night will be found useful. The foot should be held as far as it will go towards plantar flexion, and in this position a figure-of-eight bandage applied. A sufficient number of turns of the bandage should be made over the foot and ankle to hold the foot when released from the pressure of the hand in the improved position. The bandage should be changed frequently, to allow of the manipulation and massage being systematically carried on.

*Plaster of Paris Bandage.*—This method is the one usually employed in the Orthopædic Department of St. Bartholomew's Hospital. The advantages we claim for it over other methods are stated at p. 146.

After having applied the cotton-wool bandage (p. 146), and a few turns of the plaster bandage evenly and firmly over the foot and leg, draw the foot downwards towards plantar flexion as far as it will go with gentle continuous pressure, and in this position complete the laying on of the plaster bandage. The foot must be held in this corrected position till the plaster has set. If an even layer of cotton-wool of sufficient thickness is applied, and the overlying plaster bandage put on in a workmanlike manner, there need be no fear either of sores or impediment to the circulation.

The plaster should be removed at least once a week, better twice a week, and manipulation and massage practised before it is reapplied.

*Splints.*—If it is considered desirable to use a splint, the simple tin varus splint may be employed. It should be well padded, bent so as to correspond to the deformity, and gradually straighbtened out as the dorsal flexion yields. Mr. Adams applies it to the anterior aspect of the leg and dorsum of the foot, but it may be applied to the calf and sole if preferred. The foot and leg are then secured to the splint by a domett bandage. Some care is necessary in the infant to prevent pressure-sores. To avoid them, the splint should be removed daily, the bandage very carefully and evenly applied, the splint placed alternately on the front and back of the leg, and the plantar flexion of the foot only brought about very slowly. Too much haste in the use of splints in these cases is truly the less speed. Should a sore threaten, the skin should be sponged with a spirit lotion, carefully dried, sprinkled

with starch powder, covered with cotton-wool, and further pressure at this spot avoided. Should a sore form, much time will be lost, as the splint must be left off till the wound has healed. Between each application of the splint the foot should be manipulated and the leg well rubbed.

As the deformity yields the splint should be gradually straightened out, *i.e.*, straightened a little before each fresh application.

**Operative Treatment.**—Operative measures are rarely necessary, and then only in severe cases in which the foot is held rigidly in a position of dorsal flexion by the tensely contracted and unyielding anterior tendons and ligaments. In such cases, tenotomy, and more rarely syndesmotomy and forcible rectification, are indicated.

*Tenotomy.*—Tenotomy of the anterior tendons should, in our opinion, always be done by the subcutaneous method. We can conceive no reason for the open method in this situation. The tendons requiring division stand out prominently, and can be readily distinguished beneath the skin. Further, there is no important structure that can be injured if ordinary care is taken. The anterior tibial artery, or its continuation, the dorsal artery of the foot, can usually be felt pulsating, and is easily avoided by passing the tenotome between it and the tendon to be divided. The tendons that may require division for congenital talipes calcaneus are: (1) The tibialis anticus; (2) the extensor proprius hallucis; (3) the extensor longus digitorum and its external slip, the peroneus tertius.

(1) *The Tibialis Anticus* can be felt as a prominent cord passing over the internal part of the front of the lower end of the tibia to its insertion on the inner side of the foot into the internal cuneiform and first metatarsal bones. The tendon having been made tense by the assistant plantar-flexing the foot, the sharp-pointed tenotome, with the blade held on the flat, should be passed parallel to the tendon and immediately to its fibular side, gently insinuated beneath the tendon, the cutting edge then turned up towards the tendon, and the latter divided. The assistant should take care not to use too much force at the moment of division, lest the tenotome cut through the skin. The tendon is usually felt to give way with a distinct snap. A small moist pad of antiseptic gauze should be placed over the puncture whilst the other tendons are

being divided, and at the end of the operation this and the other punctures closed by a like pad of gauze, secured by strapping. The foot and limb should be then fixed in whatever form of retentive apparatus is chosen. For this purpose we employ plaster of Paris, but by many some form of splint is preferred, such as that described at p. 355. In our practice the foot after the division of the tendons is corrected as far as possible, and in this position secured in the plaster bandage. Other surgeons, however, still adhere to the older plan of fixing the foot in the deformed position for a few days, and then gradually bringing it into the plantar-flexed position by slow extension, either by means of a splint daily changed or by some form of screw apparatus, an Adams' or some other suitable modification of the Scarpa's shoe being usually employed. Mr. Adams advises that the extension should not be completed in less than three weeks.

(2) *The Extensor Proprius Hallucis.*—This tendon may be divided as it passes over the front of the ankle-joint by inserting the tenotome beneath it, through a puncture made close to its outer side. The tibialis anticus may also be divided through the same puncture by passing the tenotome further inwards beneath the tendon after the hallucis has been severed.

(3) *The Extensor Longus Digitorum and Peroneus Tertius.*—These tendons may also be conveniently divided in front of the ankle-joint when they are felt prominent. The tenotome should be introduced close to the inner or tibial side of the tendon of the extensor longus digitorum, and passed sufficiently far outwards to include the peroneus tertius.

The same manipulation on the part of the surgeon and assistant is required as in the division of the other tendons in front of the ankle-joint; indeed, all the tendons in front of the ankle may be divided through the puncture made to the inner side of the extensor longus digitorum by passing the tenotome point outwards beneath that extensor and the peroneus, and then inwards beneath the extensor proprius hallucis and tibialis anticus. If the point of the tenotome is kept close to the tendons, the anterior tibial artery is thought by Mr. Adams to run very little risk of division. Probably it is often divided unknown to the operator. If a firm pad is placed over the puncture no harm will, as a rule, follow.

*Tarsectomy.*—Only in exceptional cases can any operation of excision of the tarsal bones be required; such a case, however, occurred in the practice of Larabrie.* The foot of his patient, a lad of seventeen, was greatly distorted, and on its inner border there was a marked prominence, the centre of which was formed by the scaphoid. The tendons of the tibialis anticus, the extensor communis digitorum and peroneus tertius were very tense. It was impossible to reduce the dorsal flexion, although it could be increased by pushing the foot upwards. The patient trod only on the posterior part of the outer edge of the sole. Larabrie removed the scaphoid and parts of the adjacent bones. After the operation the patient was able to use the whole of the sole in progression, and, though an elegant foot did not result, yet its usefulness was much increased.

**Statistics.**—Of the 24 cases of congenital calcaneus that presented themselves at the Orthopædic Department during ten years, 10 were males, 14 were females. Of the total number 2 cases were severe, 4 medium, and 18 slight. Both feet were affected in 8 cases; the right only in 8 cases, the left only in 8. In 6 cases there was varus of the other foot—three times in the right, three times in the left. In 5 of the cases the extensor tendons are noted as being very tense. In 9 cases the calcaneus was associated with inversion of the sole, in 2 with eversion; in the remaining 13 cases the note is unfortunately silent on this point. It is probable, therefore, that there was neither inversion nor eversion. In 2 cases there was contraction of the knees, in 2 genu retrorsum.

## Acquired Talipes Calcaneus.

Acquired talipes calcaneus is nearly always the result of infantile paralysis affecting the muscles of the calf. Out of thirty-three cases under treatment during ten years in the Orthopædic Department, thirty-two were due to this cause. Very rarely it may be the result of joint-disease, of rupture of the tendo Achillis, of non-union of the tendo Achillis after tenotomy, of hysteria, of the contraction of cicatrices on the anterior aspect of the leg or ankle, etc.

* *Revue d'Orthopédie*, September, 1892.

**Description.**—For the purpose of description the paralytic—by far the most common—form of acquired talipes calcaneus will be taken, the rarer forms subsequently receiving a brief separate account.

In the paralytic variety so commonly met with, the flaccidity and want of tone in the foot at once suggest wide-reaching paralysis, for not only are the muscles of the calf affected, but, as a rule, the anterior and peroneal and plantar group of muscles have also suffered, though to a less extent. The tendo Achillis

FIG. 219.—PARALYTIC CALCANEUS WITH SLIGHT VALGUS IN A GIRL OF SEVEN YEARS OF AGE. (From a photograph taken in the Orthopædic Department, St. Bartholomew's Hospital.)

in many cases can be felt only with difficulty, as a flat limp band which is not made tense on strong dorsal flexion of the foot. The leg and foot are generally much wasted, and often have the sluggish circulation, bluish-red congested appearance, and the cold clammy feel so common an accompaniment of severe infantile paralysis. The foot itself has little resemblance to the congenital form. In the latter the most striking feature is the

dorsal flexion of the foot, the depression of the heel being much less noticeable. In paralytic calcaneus, on the other hand, the most marked departure from the normal is found in the depression and shape of the heel, the anterior part of the foot assuming various positions of dorsal or of plantar flexion. The heel, besides being markedly depressed (Fig. 219), appears much larger than normal, the soft tissues covering the lower part of the os calcis having become hypertrophied and spread out (Fig. 220), as it were, in consequence of the patient walking chiefly or almost entirely on the heel. But, contrary to what we should expect from the outward appearance of the heel, the posterior portion

FIG. 220.—TALIPES CALCANEUS FOLLOWING UPON INFANTILE PARALYSIS. (From a photograph taken in the Orthopædic Department, St. Bartholomew's Hospital.)

of the os calcis is often much wasted (Fig. 226, p. 368). The heel, moreover, appears large in proportion to the rest of the foot, which, on account of the general atrophy of the tissues that is nearly always met with in paralytic calcaneus (Fig. 220), is small and arrested in development. The tendo Achillis is elongated and wasted, and, instead of standing out prominently, as it does in the normal foot, lies as a narrow flattened band in close contact with the bones (Fig. 219). On taking the foot in the hand, it can be flexed without resistance, as in the congenital form, on the front of the leg.

The anterior part of the foot assumes, as mentioned above, various positions, according to the extent of the paralysis. In those rare cases in which the anterior muscles of the leg are quite unaffected with paralysis, these muscles may be found in a state of rigid contraction; the deformity then generally resembles the severer grades of the congenital affection, the foot being strongly dorsal-flexed. Only two such cases have come under our notice during the last twelve years, and in these there was, in addition to the calcaneus, marked valgus. We only possess a photograph of one of these cases in which, however, the dorsal flexion was not marked (Fig. 237, p. 384), but we append a photograph

FIG. 221.—TALIPES CALCANEUS IN A GIRL OF FOURTEEN YEARS OF AGE FOLLOWING UPON INFANTILE PARALYSIS. (From a photograph taken in the Orthopædic Department, St. Bartholomew's Hospital.)

The heel is very prominent, and the front part of the foot has dropped, producing a sharp 'cavus.' The calf is much wasted, and the extensor longus digitorum is almost deprived of any power of contraction.

from a cast in our museum (Fig. 223) in which the dorsal flexion is well seen. Hoffa* and Little† also give illustrations showing a similar condition.

More commonly, however, the anterior muscles are, to a greater or less extent, affected as well as the posterior muscles, and the foot, instead of being in a condition of dorsal flexion, presents the

* Hoffa, *op. cit.*, Fig. 510, p. 706.
† Little, *op. cit.*, Fig. 57, p. 157.

Fig. 222.—Calcaneo-Valgus following Infantile Paralysis. (From a photograph taken in the Orthopædic Department, St. Bartholomew's Hospital.)

The large and prominent heel is well seen. The front part of the foot was much wasted as compared with that on the right side.

Fig. 223.—Calcaneo-Valgus Paralyticus, with the Foot in Dorsal Flexion, consequent on Contraction of the Anterior Muscles of the Leg. (From a photograph of a cast in St. Bartholomew's Hospital Museum.)

appearance shown in Fig. 221, the typical condition in our experience of paralytic calcaneus. The fore part of the foot, it will be seen, drops downwards at the transverse tarsal joint, so that the sole is unnaturally concave. Various degrees of this condition may be met with, and are well shown in Mr. Little's work on deformities.* In the slighter forms there is merely a slight increase of the plantar arch; in the most severe the arch is so increased in depth that the foot resembles that of the Chinese lady (Fig. 224). In brief, the foot presents the appearance seen in pes cavus, a condition so commonly met with in talipes equinus and rectangular talipes (p. 258). The arch, however

Fig. 224.—Photograph of the Foot of a Chinese Lady. (St. Bartholomew's Hospital Museum.)

in severe forms of calcaneus is much sharper than in cavus, and more abrupt; but it is, perhaps, most abrupt in cases in which the calcaneus is associated with valgus, since in such the peroneus longus escapes the paralysis, and, at the same time as it gives rise to the eversion, also approximates the first metatarsal bone to the heel. In the slighter cases the depressed fore part of the foot can be somewhat raised, and the arch correspondingly straightened out; but in severe cases the parts become rigid, and the arch cannot be diminished by manipulation. Nicoladoni has especially called attention to these severe forms of talipes cal-

* Little, Figs. 58 and 59, p. 158.

caneus unattended with dorsal flexion of the foot, and speaks of them as 'talipes calcaneus sensu strictiori,' in contradistinction to the forms in which there is dorsal flexion, which he calls 'talipes calcaneus sursum flexus.' It has been commonly taught that this dropping down of the fore part of the foot is secondary to an earlier condition, in which the foot is in the position of slight dorsal flexion. The anterior muscles being only slightly affected by the paralysis, at first draw the foot into dorsal flexion; but as the patient walks, the heel comes first to the ground, and then, partly as the result of gravity, and partly as the result of the patient voluntarily relaxing the anterior muscles, the front part of the foot becomes bent downwards, and so in contact with the ground. In the meanwhile, the gastrocnemii being paralyzed, the plantar muscles approximate the tuberosity of the os calcis towards the heads of the metatarsal bones, thus deepening the plantar arch.

Nicoladoni explains the cavus deformity in a similar way, except that he does not admit that the foot has ever been in a position of dorsal flexion. According to his view, the anterior muscles, the peronei, and the short flexors of the foot are intact, whilst the superficial and deep muscles of the calf are paralyzed. The anterior muscles maintain the os calcis in its almost vertical position, whilst the peronei and the plantar muscles draw its tuberosity and the heads of the metatarsal bones towards each other, thus deepening the arch, and causing the patient to walk upon the posterior ends of the os calcis and heads of the metatarsal bones.

So far, we have never been able to obtain any evidence in these cases that at one time there was dorsal flexion, or, at any rate, such a degree of dorsal flexon as to direct the parents' attention to it. No doubt, as Mr. Little showed in his work on deformities,* the foot passes through various grades before it reaches the condition described; but an attentive perusal of his work does not convince us that, in these cases, there has been at one time any marked dorsal flexion of the anterior part of the foot. If such existed in his cases, it is certainly not brought out in his diagrams.

We have not had the opportunity of following this movement,

* Little on Deformities, p. 158.

and we do not learn from those authors who give this explanation whether they have actually seen a case, in which there was at one time dorsal flexion, gradually assume the familiar cavus form.

Here it may be remarked that, in cases of infantile paralysis—in which the anterior muscles and the peronei as well as the superficial and deep muscles of the calf are affected, that is, where all the muscles of the leg are paralyzed—the foot, by reason of its weight, falls into the position of equinus, so that in calcaneus there must be always some power left in the anterior muscles or in the peronei to maintain the os calcis in a position of dorsal flexion, and depress its posterior extremity. In brief, therefore, when the anterior muscles entirely escape, the foot is dorsal-flexed; when they are only to some extent affected, the anterior part of the foot drops forward, and more or less cavus is produced, according to the extent of the paralysis of the anterior muscles; and when they are entirely paralyzed equinus, and not calcaneus, is the result.

### Etiology of Acquired Talipes Calcaneus.

By far the most common cause of acquired talipes calcaneus is infantile paralysis, affecting the superficial muscles of the calf, and in various degrees the other muscles of the leg and foot. More rarely the following conditions have led to the deformity.

1. Non-union of the tendo Achillis after tenotomy, rupture or other injury of that tendon.

2. Faulty or elongated union of the tendo Achillis, following tenotomy or rupture. Mr. Adams speaks of non-union or faulty union after tenotomy as common, and Mr. Little and others have met with such cases. We can only repeat that, although we have not infrequently left as much as two inches or more between the divided ends, we have never met with calcaneus from this cause, and such a case has not hitherto presented itself in the Orthopædic Department. We cannot therefore help regarding this condition as very rare.

3. Ankylosis of the ankle-joint after inflammation, with the bones in the position of dorsal flexion. Fig. 225, taken from Hoffa, is a unique example of this.

4. Phlegmonous inflammation of the sole, occurring in one case spontaneously, in the other as the result of the accidental introduction of a piece of glass. Here the deformity was the result of the patient walking with the sole raised in the position of calcaneus until this position of the foot became permanent. The muscles of the calf in these cases were wasted, and the os calcis

Fig. 225.—Talipes Calcaneus the Result of Disease of the Ankle-joint. (From Hoffa.)

had become pathologically curved under the influence of the weight of the body.

5. Cicatrices on the dorsum of the foot, the result of burns; arge wounds or ulcers are occasionally the cause of a kind of calcaneus.

6. Hysteria.

### Morbid Anatomy of Acquired Talipes Calcaneus.

The morbid changes met with in acquired calcaneus necessarily vary according to the cause of the deformity. In by far the greater number of cases met with, infantile paralysis, as we have just seen, is the cause, and this form will first receive attention.

In all, the essential factor is, of course, paralysis of the superficial or great muscles of the calf, namely, the gastrocnemius and soleus; the deep muscles of the calf, namely, the flexors of the toes and the tibialis posticus, and the remaining muscles of the leg and foot may be variously affected or escape, thus producing various modifications of the deformity.

Two chief forms of paralytic calcaneus, whether associated or not with valgus or varus, are described: One in which the foot is found in a position of dorsal flexion; the other in which there is no dorsal flexion of the foot, and, though the posterior tuberosity of the os calcis is depressed, the anterior part of the foot with the toes, instead of pointing upwards, is bent downwards on the os calcis at the transverse tarsal joint, so that the plantar arch is much increased in depth.

*In the first form* (pes calcaneus sursum flexus, Hoffa, Nicoladoni), in the early stages, beyond paralysis of the calf muscles and fixation of the foot in the dorsal-flexed position by the contracted anterior muscles and ligaments, nothing special in noticeable in the position and shape of the bones, though later they may present some of the changes already given under the congenital variety.

*In the second form* (pes calcaneus sensu strictiori, Hoffa, Nicoladoni) there is no dorsal flexion of the anterior part of the foot, but the tuberosity of the os calcis is depressed, and the anterior part of the foot bent downwards at the transverse tarsal joint, exaggerating the plantar arch. This is the condition of the foot which, in our experience, is the one commonly met with. According to Nicoladoni and Hoffa, this form is not preceded by dorsal flexion, the toes never having pointed upwards. It is explained as due to paralysis of the superficial and deep calf muscles, whilst the dorsal flexors, the peronei, and the short flexors of the foot, remain intact. The peronei and the plantar

muscles pull upon the os calcis and the metatarsal bones, and so approximate them, thus materially deepening the plantar arch. The direct pull of the plantar muscles upon the os calcis causes its posterior process to become the inferior, as is well seen in Fig. 226.

Some authors, as Messrs. Little and Adams, would appear to regard the second form as always secondary to the first, and brought about in a way already mentioned at p. 364.

**The Bones.**—The bones chiefly affected are the astragalus and os calcis, and the changes they undergo are similar to those already described in the congenital form.

Fig. 226.—Photograph of a Skeleton of Talipes Calcaneus in an Adult following upon Infantile Paralysis in Early Infancy. (St. Bartholomew's Hospital Museum.)

The first metatarsal bone and its two phalanges are wanting. The forward position of the tibia on the neck of the astragalus, and the vertical direction of the long axis of the os calcis, are well seen.

The inferior articular surface of the **Astragalus**, in consequence of the extreme position of dorsal flexion in which this bone is placed, undergoes atrophy posteriorly, and loses its cartilage; whilst in front the facet extends forward on to the neck of the bone. The irregular forward extension of this facet, and the atrophy of its posterior portion, are well shown in the accompanying photograph (Fig. 227).

**The Os Calcis** assumes an almost vertical position, so that its

posterior tuberosity rests upon the ground, and its long axis looks nearly directly upwards, instead of upwards and forwards. The posterior end is atrophied, and smaller than normal (Fig. 226);


FIG. 227.—PHOTOGRAPH OF AN ASTRAGALUS FROM A CASE OF PARALYTIC CALCANEUS IN AN ADULT, SHOWING THE EXTENSION FORWARDS (A A) OF THE SUPERIOR ARTICULAR SURFACE UPON THE NECK OF THE ASTRAGALUS, AND THE ATROPHY OF THE POSTERIOR PORTION OF THE ORIGINAL TROCHLEA. (St. Bartholomew's Hospital Museum.)

The dotted line marks the atrophied portion (B). The continuous white line shows the extent of the articular surface. The black line is a flaw in the negative.

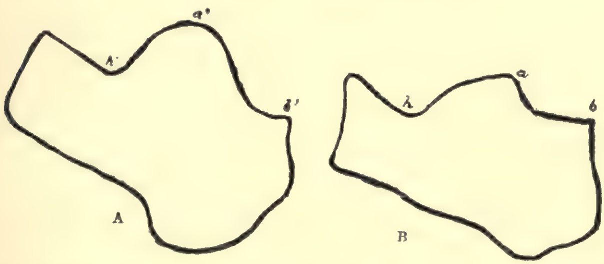



FIG. 228.—LONGITUDINAL SECTION OF THE OS CALCIS (A) IN TALIPES CALCANEUS, (B) IN NORMAL FOOT; $h$ $a$ AND $h'$ $a'$ POSTERIOR ASTRAGALOID FACET, $a$ $b$ AND $a'$ $b'$ POSTERIOR PART OF SUPERIOR SURFACE. (After Hoffa and Nicoladoni.)

its anterior end is greatly atrophied, and may appear almost wanting.

In the normal os calcis the posterior part of the superior surface behind the posterior astragaloid facet runs backwards to the tuberosity in a gentle curve, with its concavity upwards; in paralytic calcaneus this surface takes an S-shaped form, and runs more downwards than backwards. This condition is well shown in the accompanying outlines of longitudinal sections of the normal and pathological os calcis (Fig. 228).

The remaining bones are little if at all altered in shape; but the bones in front of the os calcis and astragalus become depressed at the transverse tarsal joint, so that the foot, as seen in

FIG. 229.—PHOTOGRAPH OF A DISSECTION OF A SPECIMEN OF TALIPES CALCANEUS FROM A YOUNG ADULT FOLLOWING UPON INFANTILE PARALYSIS IN INFANCY. (St. Bartholomew's Hospital Museum.)

All the posterior muscles are completely converted into fat, the anterior muscles being partially degenerated. The smallness of the end of the calcis, and the vertical position of the bone, are well seen. The weight of the skin and subcutaneous tissue, which latter was enormously hypertrophied, and consisted solely of adipose tissue, was equal to that of the rest of the leg and foot. See Fig. 230.

Figs. 229 and 231, assumes the shape of talipes cavus. The tuberosity of the os calcis, however, is depressed in place of being raised, as it is in the common form of cavus associated with talipes equinus, or with right-angled contraction of the tendo Achillis. The arch, too, is higher than in ordinary cavus, and its sides steeper and not symmetrical. Its resemblance to the

arch in the foot of the Chinese lady was long ago pointed out by Mr. Little, and has struck all writers on the subject since. The tuberosity of the os calcis and the bases of the metatarsal bones are, however, as remarked by Mr. Adams, on the same level; whereas in the foot of the Chinese lady the tuberosity of the os calcis is on a higher level than the bases of the metatarsal bones, and her shoe has the heel raised, and the sole sloping downwards from the heel to the toes.

**The Ligaments and Fasciæ.**—The anterior ligaments become gradually contracted and shortened, and the anterior portions of the internal and external ligaments share in the shortening. The posterior ligament and posterior portion of the internal and external lateral ligaments have been found stretched and elongated. The plantar fasciæ, with the calcaneo-scaphoid and calcaneo-cuboid, and other plantar ligaments, have been found shortened and contracted.

FIG. 230.—THE SAME FOOT AS SHOWN IN FIG. 229 BEFORE DISSECTION.

**The Muscles.**—The gastrocnemius and soleus are necessarily always to a greater or less extent involved in the paralysis, and in the majority of cases have been found reduced to little more than masses of fat. At times, however, some portions of these muscles apparently may escape. The tendo Achillis, in place of standing out prominently at the back of the heel, is reduced to a thin flattened band, lying, as well seen in Figs. 229, 231, in contact

with the astragalus and os calcis. The remaining muscles may be variously involved in the paralysis; and according as this or

Fig. 231.—Photograph of the same Specimen as in Figs. 229, 230, seen from the Outer Side.

that muscle, or group of muscles, is or is not paralyzed, so does the foot assume various shapes. Thus, we have seen that when

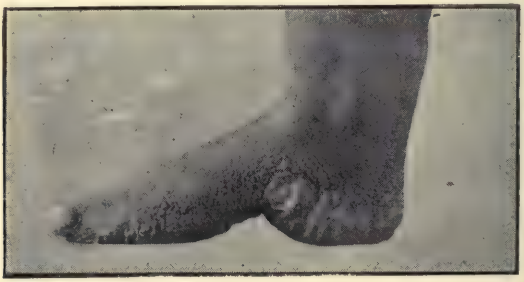


Fig. 232.—Talipes Calcaneus following upon Infantile Paralysis. (Photograph of the same specimen as shown in the three preceding figures.)

the anterior muscles or dorsal flexors alone remain unparalyzed, the foot assumes the position of dorsal flexion at the ankle-joint.

When, as well as the dorsal flexors, the peronei and small plantar muscles escape, we have the cavus form.

*Detailed Description of the Skeleton of a Foot of an Adult who had suffered from Talipes Calcaneus the Result of Infantile Paralysis in Early Life.*

All the bones are small and ill developed, the result of paralysis in early life. The foot and leg, as a whole, before dissection (Fig. 232) presented well-marked features of the paralytic variety of the deformity, with depression of the anterior part of the foot, and increase in depth of the plantar arch. The skin, with the subcutaneous tissue, which was enormously hypertrophied, and consisted solely of adipose tissue, weighed, when removed, as much as the remaining portion of the leg and foot.

The posterior muscles, both superficial and deep, were completely converted into fat. The anterior muscles were affected to a less degree.

*The Os Calcis* is almost vertical, its posterior dorsal portion lying quite in a vertical plane. The postero-external facet for articulation with the astragalus, and the antero-internal facet on the upper surface of the sustentaculum tali, looked directly upwards. The plantar surface is somewhat curved, with the concavity looking forwards and downwards. The original articular facet for the cuboid looks upwards and forwards. The anterior part of the bone has not been so much displaced from its original position as the posterior part, the two portions forming almost a right angle with each other. The portion of the bone between the postero-external astragaloid articulation and the surface walked upon is much longer, comparatively, than in the normal bone, being about two-thirds of the whole length of the bone, while in the os calcis of the normal foot it is only about one-half. Moreover, the present posterior surface, which is made up of the posterior part of the postero-external articular facet and the upper two-thirds of the original posterior surface, runs in an almost vertical uninterrupted line directly downwards from the articular surface of the astragalus, there being a slight forward bend of the lower half, thus forming a convexity looking backwards and downwards. The surface of the bone walked upon is

formed by the lower part of the original posterior surface, so that the inferior tubercles occupy a position on the present anterior surface (the original plantar surface), the outer tubercle being about an inch in a vertical line from the extremity of the new heel. The insertion of the tendo Achillis is represented by a smooth surface. The *cuboidal facet*, in consequence of the cuboid being depressed, is denuded of cartilage in its upper part, whilst a new articular surface has been formed for the cuboid on the adjacent plantar surface of the bone. This surface encroaches upon the depression for the calcaneo-cuboid ligament. The *sustentaculum tali* is very small and ill developed, and the articular surface on it for the astragalus looks directly upwards. The posterior part of the postero-external articular facet is exposed in consequence of the forward displacement of the astragalus, the posterior edge of the latter bone being almost on a line with the posterior point of the sustentaculum tali.

*The Astragalus.* — The astragalus, in its general contour, resembles a normal astragalus, but presents many marked modifications. The trochlea posteriorly resembles the infantile form; anteriorly it is prolonged further forwards on the neck than normal. These new articular facets on the neck (see Fig. 227) are tongue-shaped, and run almost the whole extent of the original neck. The *external malleolar facet* is moved anteriorly, and is rather narrower antero-posteriorly than in the normal bone. Its posterior portion has completely disappeared; anteriorly it runs into the prolonged anterior articular facet on the upper surface of the neck. The *internal malleolar facet* is prolonged forward in a straight line, continuing the line of the original articular surface. The whole bone posteriorly is increased in depth, and is equal to the deepest part of the bone, namely, that corresponding to the point of the external malleolar facet. The neck is prolonged and depressed from above downwards; in length it is almost equal to the rest of the bone, whilst in depth it is only equal to about half the deepest portion of the bone. In a normal bone the antero-posterior measurement of the neck is rather less than half the rest of the bone, and its greatest depth is nearly equal to that of the bone at the point of the external malleolar facet. On the posterior surface the groove for the flexor proprius hallucis is well marked.

*The Scaphoid.*—The tubercle is represented by a very small prominence of bone. The bone itself is small, though its antero-posterior diameter is relatively large.

All the bones in front of the mesio-tarsal bone are depressed as a whole directly downwards; the upper portions, therefore, of the articular surface of the astragalus and os calcis, for the scaphoid and cuboid respectively, are exposed and denuded of cartilage. The bones of the anterior part of the foot maintain their normal relations to each other, though they form a very acute angle with the os calcis and the astragalus.

The morbid anatomy of the non-paralytic forms of acquired talipes calcaneus may be very briefly dismissed. Hoffa gives in his book on 'Orthopædics,' an illustration of the foot and the bones of the leg ankylosed, in the position of calcaneus. The heel is depressed, the toes point upwards; but no account is appended of the condition of the soft tissues (Fig. 225).

As regards the other rare forms that have been described, such as those due to the non-union, or weak union, of the tendo Achillis after rupture, we know of no description of the state of the parts, nor, indeed, of any examination in such cases having been made. One would imagine, however, that similar changes to those already described would ensue in the bones and ligaments, and that the muscles would be wasted and atrophied from want of use.

**Signs and Diagnosis.**—In the earlier stages, except the rare cases in which there is dorsal flexion, there may be no evident deformity of the foot. The parents will probably complain, however, that the child is weak in the affected leg, that he has 'been taken off his feet;' walks lame, or that the ankle projects. As the muscles begin to waste, the signs of infantile paralysis already mentioned will begin to show themselves; and, on inquiry, the history of an attack of infantile paralysis will probably be forthcoming, *i.e.*, weakness or lameness of one leg coming on after measles, whooping-cough, or convulsions, or coming on suddenly, without apparent fever or other noticeable ailment. On taking the foot in the hand, it will be found there is a want of tone in the muscles, and that it can be dorsal-flexed to an abnormal degree, perhaps laid with the dorsum on the front of the leg. If the

finger is placed over the tendo Achillis whilst the dorsal flexion is being made, the muscle will not be felt to stand out prominently, as it should do in health. Later, the wasting of the calf, and the characteristic appearances of the foot already mentioned, will make the diagnosis plain. The patient walks in a peculiar manner: the heel is first placed on the ground, and then the fore part of the foot flaps, as it were, down. The heel of the boot is, in consequence, often quite worn down posteriorly. If asked to stand on tiptoe with the sound leg off the ground, the patient is unable to do so. An electrical examination will reveal the exact state of the muscles, and show which are affected and which have escaped.

**Prognosis.**—The prognosis, always unfavourable, will depend upon the extent of the paralysis. When the calf muscles alone are affected, a better result will be obtained than when the peronei and some of the anterior group share in the paralysis. If portions of the calf muscles escape, the prognosis will be still better. Again, when the paralysis is confined to one side and to the leg, the case is more amenable to treatment than when the deformity is bilateral, and the thigh muscles are, to a greater or less extent, involved. The most hopeless cases are those in which the muscles running from the pelvis to the thigh suffer with the rest, especially when both sides are affected, and there is some paralysis also of the back muscles. But even in such cases something can be done to relieve the distressing condition. Under the most favourable circumstances the affection, being due to paralysis, is, of course, incurable.

**Complications.**—The complications that may be met with in acquired talipes calcaneus are such as may result from paralysis involving other muscles of the limb, as the quadriceps extensor of the knee, the hamstrings, or some of the muscles which extend between the pelvis and the thigh. In rare instances the muscles of the upper extremity may also be affected with paralysis; but this cannot, in the strict sense of the word, be looked upon as a complication of talipes calcaneus.

### Treatment of Acquired Talipes Calcaneus.

The treatment of acquired talipes calcaneus necessarily differs, according to the cause of the deformity. This, as we have already seen, in by far the greater number of cases is infantile paralysis. What follows will have special reference to the treatment of paralytic cases. The treatment will be considered under the heads of physiological, mechanical, and operative.

**Physiological Treatment.**—This consists in massage of the affected muscles, and electrical stimulation, such as is called for in other forms of infantile paralysis. Long continuance of this treatment, systematically carried out in the Electrical Department of the hospital, has in some apparently almost hopeless cases been of very considerable benefit.


FIG. 233.—BOOT AND IRONS, WITH TOE-DEPRESSING SPRING, FOR CALCANEUS.

**Mechanical Treatment.**—This has for its object the prevention of increase of the deformity, and the improvement in the form of the foot and its usefulness in walking. Mechanical apparatus is of most service in the early stages of calcaneus, before extreme depression of the posterior tuberosity of the os calcis has taken place, and the anterior part of the foot has dropped downwards at the medio-tarsal joint, and the foot in consequence assumed the cavus shape, as shown in Fig. 221. The following appliances are perhaps most in use:

1. *The Heel-raising or Toe-depressing Spring.*—The object of this apparatus, as the name implies, is to raise the heel and depress the anterior part of the foot—*i.e.*, to supplement or supply the place of the calf muscles. The force is applied either in the form of a steel spring or in that of a rubber cord or ring. An illustration is given of each, but there are many modifications in vogue. Fig. 233 consists of a walking-boot, to which is attached two lateral side-irons with a free joint at the ankle. The irons are fixed above to a well-padded steel calf-circlet. The spring is fixed to the outer iron. Fig. 234 is a similar boot and irons, but,


FIG. 234.—APPARATUS FOR CALCANEUS.

Rubber accumulator attached behind the leg to the calf-piece and heel of boot so as to raise the heel, and thus supply the place of the paralyzed calf muscles.

in place of a spring, a leather strap in which an indiarubber cord is intercalated runs behind the leg, from the heel of the boot to the calf-circlet. We usually ourselves employ a steel spring, since it lasts longer, is less in the way, and on the whole, we think, does its work better than the rubber accumulator. The accumulator, however, is cheaper.

2. *The High-heeled Boot with an Anterior Stop-joint.*—The boot is provided with two lateral irons, attached above to a calf-circlet; but the joint at the ankle is so formed as to prevent

dorsal flexion of the foot beyond the right angle. This apparatus is recommended by Mr. Adams in slight cases for preventing the increase of the deformity. Whilst in use, he employs during the night a slipper with a metal sole-plate to keep the sole of the foot flat.

3. *Judson's Apparatus* consists of an upright and a foot-piece, the joint between the two being so constructed that the foot-piece falls, but cannot be raised beyond a right angle with the upright. The foot and leg are attached to the foot-piece and the upright respectively, and, as these component parts of the brace cannot be flexed the one on the other past a right angle, it follows that in standing and walking the foot will remain at right angles

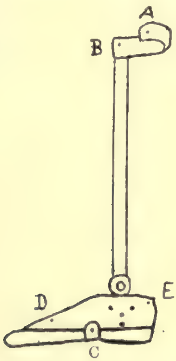



FIG. 235.—JUDSON'S APPARATUS.

FIG. 236.—JUDSON'S APPARATUS APPLIED.

with the leg. Fig. 235 represents the steel frame of such a brace for the right foot; buckles are attached at A, B, D and E. A strap passes from A to B across the front of the leg, and another riveted at C has two free ends, one of which is buckled at D and the other at E. A consideration of the action of this brace shows that it transfers to the vicinity of the tubercle of the tibia the pressure and friction which ordinarily fall on the sole of the foot (Fig. 236).

**Operative Treatment.**—Several operations have been proposed and practised for the relief or cure of acquired talipes calcaneus. They have for their objects: (1) the shortening of the elongated tendo Achillis; (2) the substitution of a healthy muscle for the paralyzed gastrocnemius and soleus by attaching a neighbouring

healthy muscle to the divided lower end of the Achilles tendon; (3) the correction of the abnormal concavity of the sole by the subcutaneous division of the resisting structures therein; (4) the fixation of the foot at a right angle to the bones of the leg; (5) the correction of the dorsal flexion of the foot by tenotomy of the anterior tendons.

1. *Shortening of the Achilles Tendon.*—This operation is only of service when some muscular tissue remains in the gastrocnemius and soleus. When these muscles are completely paralyzed, and have undergone fatty degeneration, the shortening of the tendo Achillis is useless. At the time of operation, and for some time subsequently, the foot is held in a better position; but as soon as the patient begins to walk, the fatty muscle gradually yields, and the condition of the foot is soon as bad as before the operation. Prior, therefore, to undertaking the shortening of the tendo Achillis, a very careful examination as to the electrical condition of the calf muscles should be made; and if, as the result of such examination, it is clear that complete degeneration has taken place, then no operation should be undertaken.

Conversely, if the electrical examination shows that there is some healthy muscle-tissue left, it is well to postpone the shortening of the tendon till as much good as possible has been obtained by a systematic course of electrical treatment, combined with massage of the calf-muscles. Where these muscles are in a fair condition—unfortunately the exception rather than the rule—then the shortening may be undertaken at once. In applying electrical tests it may be here mentioned that some error may creep in, especially when the patient, as is perhaps generally the case, is an unruly child, in that the current may be transmitted to the deeper muscles of the leg, and some action of the calf muscles thus simulated. Where there is any doubt, therefore, whether the calf muscles do or do not respond to the electrical test, the patient should be examined under an anæsthetic.

If the case appears suitable, the shortening of the Achilles tendon may be done by one of the following methods:

(*a*) *Willett's Method of shortening the Tendo Achillis.** (*Tenectomy.*)—'A Y-shaped incision, some two inches in length,

* Willett, 'St. Bartholomew's Hospital Report,' vol. xvi., 1880, p. 309.

is made over the lower end of the tendo Achillis down to the tendon. At the lower or vertical portion of the incision the dissection is continued until the tendon is fully exposed over its superficial and lateral surfaces for the space of one inch in length, its deep connections being left undisturbed. The tendon is now cut across at the point of junction of the oblique portions of the wound with the vertical. Next, the proximal portion of the tendon is raised, with its superficial connections to the integuments undisturbed, to the extent of fully three-quarters of an inch, by dissecting along its deeper surface, *i.e.*, by reversing the dissection made upon the distal segment. A wedge-shaped slice of the tendon is now cut off from both segments, that from the proximal being removed from the deep surface, whilst from the distal it is taken from the superficial; in both instances the faces of the wedge-shaped portions removed being at the point where the tendon has been divided. The heel being now pressed upwards, the proximal portion, including both skin and tendon, is drawn down and placed over the distal, thus bringing the prepared cut surfaces of the tendon into apposition. In this position they are held by an assistant whilst four sutures, two on either side, are passed deeply through the integument, then through both portions of the tendon, and again out through the integument, and fastened. When the operation is completed, the united edges of the wound assume a **V**-shaped appearance, owing to the angle of the proximal portion being now attached to the terminal point of the distal portion of the original incision.' Mr. Willett considers his operation especially applicable to those cases in which both feet are affected with calcaneus. He publishes such a case, where the results were most satisfactory. He believes that the method formerly adopted of merely removing a piece of the tendon and suturing the divided ends was faulty, and more likely to fail than to succeed. The cicatricial tissue filling up the gap between the divided ends, he says, will be simply fibrous tissue, and not homogeneous in structure with the tendon, and therefore likely to yield, notwithstanding that the gap between the ends is lessened by keeping the heel raised during the healing stage.

Dr. Gibney has somewhat modified Mr. Willett's method. He employs a **Y**-shaped incision, but does not remove a portion of

the tendon. The incision through the latter is made very oblique, from below upwards and from behind forwards; the upper segment is then slid downwards upon the lower, and the two portions sutured by catgut, with the foot in position of extreme plantar flexion.

We have performed Willett's operation on several occasions, and, where any muscular tissue was left in the gastrocnemius and soleus, have obtained excellent results. When these muscles, however, were completely paralyzed we have been disappointed. Nothing could be more satisfactory than the condition of the patients on leaving the hospital; but after they had walked for some months on the foot, the tendon, which immediately after the operation stood out from the heel in the normal manner, appeared to become again elongated, and lay, as before the operation, close to the bones. We do not believe this was the result of the yielding of the material uniting the sutured ends, but rather the giving way of the tendon where it joined the muscular fibres, or of the fatty muscular fibres themselves becoming elongated. In these cases, neither before nor subsequently to the operation could our electrical officer, the late Dr. Steavenson, detect any reaction to his tests in the calf muscles, and although one of the patients attended as an out-patient in the Electrical Department for many months, no improvement was obtained. Unless, therefore, electrical tests show that some healthy, though perhaps wasted, muscle fibres remain in the calf muscles, we do not advise the shortening of the Achilles tendon, but rather trust to mechanical apparatus, or to the substitution of healthy muscle for the paralyzed, as proposed by Nicoladoni.

(*b*) *Shortening the Tendo Achillis by transplanting the Tubercle of the Os Calcis.*—In order to avoid any risk of the tendo Achillis not uniting, or of the uniting material yielding or stretching subsequently to the operation, Mr. Walsham has practised the transplantation of the tubercle of the os calcis with the tendo Achillis attached.

A vertical incision about four inches long is made over the centre of the lower portion of the tendon, and is carried downwards well over the point of the heel. The sides of the wound are retracted; the lateral margin of the tendo Achillis immediately above its insertion into the bone is defined, and a director

passed beneath the tendon. A keyhole-saw is next slid along the groove of the director, its cutting-edge turned downwards, and a portion about half an inch thick of the os calcis cut through, the saw emerging on the under surface of the bone. During this procedure the skin flaps must be well retracted. To obtain enough room, the first or skin incision must be carried sufficiently far forward along the under aspect of the heel. If this has not been done, it must at this stage be prolonged. It should have been carried through the fatty tissue of the heel down to the bone. The lower half-inch or so of the posterior detached end of the os calcis is now cut off, and the upper end of this portion, to which the tendo Achillis remains attached, is drawn down and fixed by an ivory peg to the lower part of the section of the posterior surface of the os calcis. Whilst this is being done, the foot is held in the position of extreme plantar flexion. The wound should then be completely closed with sutures. Strict antiseptic precautions should be observed both before, during and after the operation. The foot and lower half of the leg is then encased in a plaster of Paris bandage, the foot being maintained in a position of plantar flexion. The plaster should be kept on for a month or six weeks. The wound in our case healed by the first intention, and on the removal of the dressings the transplanted portion of bone was found firmly united.

2. *The Substitution of a Healthy Muscle for the Paralyzed Gastrocnemius and Soleus* (*Nicoladoni's Operation*).—Nicoladoni, for cases in which the gastrocnemius and soleus are completely paralyzed, recommends the grafting of the tendons of the healthy peronei into the lower end of the tendo Achillis. An incision about five inches in length is made along the anterior border of the peroneal tendons, terminating at the external malleolus below. A second incision is carried horizontally backward from the first, so as to allow a flap being raised and the peroneal tendons being detached from their groove behind the malleolus and divided without separating the longus from the brevis. At the same spot a portion of the tendo Achillis, about three inches in length, is removed from the outer margin of the tendon, and on to the refreshed surface thus formed the peronei tendons are sutured by fine silk. The healthy muscular belly of the peronei is thus substituted for the paralyzed gastrocnemius and soleus.

3. *The Correction of the Abnormal Concavity of the Sole by the Subcutaneous Division of the Plantar Fascia or other resisting Soft Tissues.*—We have not met with a case in which such a procedure seemed desirable ourselves, but in exceptional cases, as those in which the deformity is due to causes other than paralysis, we can conceive that some benefit might be obtained.

4. *Fixation of the Foot at a Right Angle to the Bones of the Leg by Resection of the Ankle-joint* (*Arthrodesis*) is justifiable only in exceptional cases, namely, those in which the foot is flail-like, consequent on paralysis of all the muscles of the leg. An account of this operation is given under 'Equinus' (p. 304).

5. *Correction of the Dorsal Flexion* by division of the anterior tendons may be said seldom to be required in paralytic cases, but may be called for in certain conditions, such as contractions of

FIG. 237.—SLIGHT CALCANEO-VALGUS IN A BOY OF SIX YEARS, FOLLOWING UPON INFANTILE PARALYSIS. (From a photograph of a patient attending the Orthopædic Department, St. Bartholomew's Hospital.)

The anterior muscles were very tensely contracted, and resisted all attempts at reduction by manipulation.

the soft tissues on the front of the leg involving these tendons, conditions sometimes met with after burns, wounds, etc.

**Statistics of Acquired Talipes Calcaneus.**—During ten years there were 33 cases of acquired calcaneus under treatment. Of these 13 were males, 20 females. In all but one, a hysterical case, the deformity was the result of infantile paralysis. Thirteen cases were associated with valgus; 1 with varus; 1 with strongly-flexed toes; 3 with very strongly-marked cavus; 2 with contraction of the anterior tendons; 1 with contraction of the peronei; 1 with

genu retrorsum. In 11 the right foot only was affected, in 7 the left foot only; in one of these there was equino-varus of the other foot.

**Talipes Calcaneo-Valgus and Calcaneo-Varus.**

Talipes calcaneo-valgus and talipes calcaneo-varus are mere varieties of talipes calcaneus, but are described by some writers as distinct deformities. In the description of talipes calcaneus it was stated that both in the congenital and in the acquired form some eversion or inversion of the fore part of the foot is common. In slight cases of calcaneus we contend, contrary to the general statement of writers on the subject, that the sole more often looks slightly inwards than outwards. In the severer cases of calcaneus, with distinct eversion or inversion of the foot, that is, with eversion or inversion sufficient to place the deformity under the denomination of calcaneo-valgus or calcaneo-varus, eversion or valgus is undoubtedly much more frequently met with than inversion or varus. In fourteen cases in the Orthopædic Department of the compound deformity, thirteen were valgoid, only one varoid. The greater frequency of calcaneo-valgus, at least in paralytic cases, is probably due to the peronei muscles, the active agents in producing the eversion, having a different nerve supply, and thus escaping. The superficial and deep calf muscles are supplied by branches of the internal popliteal, the peronei and anterior group of muscles by the external popliteal. In calcaneo-valgus the eversion is due to the anterior muscles and the peronei not being affected, or affected to a much less extent than the calf muscles. In calcaneo-varus the inversion is due to the peronei being more deeply affected than the rest of the anterior muscles, the opponent of the peronei, the anterior tibial muscle, drawing the leg into the varus position.

Duchenne, who has worked especially at the subject, makes the following varieties of paralytic calcaneus:

1. Talus pied creux direct = ordinary talipes calcaneus without marked eversion or inversion. This form is the result of paralysis of the calf muscles, the anterior muscles escaping.

2. Talus pied creux tordu en dehors = talipes calcaneo-valgus. Here in addition to the paralysis of the calf-muscles the flexors of

the toes are paralysed, but the peroneus longus is intact. The arch of the foot is thus increased in depth, and the sole is everted.

3. Talus pied creux varus = talipes calcaneo-varus. In this variety the calf-muscles are paralysed, as is also the peroneus longus, the remaining muscles escaping. The foot is consequently inverted by the tibialis anticus, and the toes are flexed and the arch is increased in depth by the long flexors of the toes.

4. Talus pied plat direct = talipes calcaneus with flattening of the sole. This form is due to paralysis of the peroneus longus as well as the calf-muscles, the extensors of the toes and tibialis anticus remaining intact.

5. Talus pied plat varus = talipes calcaneo-varus with flattening of the sole. In this, in addition to the paralysis of the calf-muscles and flexors of the toes, the extensors are weakened, the tibialis anticus being alone unaffected with paralysis.

Nothing further as regards the etiology, pathology and treatment of calcaneo-valgus and calcaneo-varus need be added to what has already been said under the heads of Congenital and Acquired Talipes Calcaneus.

# CHAPTER X.

## TALIPES VALGUS.

**Synonyms.**—Flat-foot; Atonic valgus; Spurious valgus; Splay-foot; Splaw-foot; Pes pronatus acquisitus; Pes flexus pronatus reflexus; Pes valgus staticus vel adolescentium; Pied bot valgus; Pied plat; Pied plat valgus douloureux; Plattfuss; der statische Plattfuss; Piede piatto; Piede valgo.

**Definition.**—Talipes valgus, or flat-foot, is a condition in which the natural arching of the foot is lost, the sole is flattened on the inner side, and the foot is everted and abducted at the medio-tarsal and subastragaloid joints.

Some writers, as Rédard, draw a distinction between pes valgus and pes planus, and undoubtedly in exceptional cases either the valgus position or the flattening of the arch may be the more marked feature. As we hold, however, that there cannot be flattening of the arch without more or less abduction, we shall describe the valgus and planus together under the term talipes valgus.

Talipes valgus may be divided into two chief classes—the congenital and the acquired. The latter is exceedingly common; the former is, comparatively speaking, rare.

### Congenital Talipes Valgus.

The feet of new-born children are flat, and although there is an inherent tendency for the bones in their development to take the shape and position of the bones in the normal adult foot, it is not until the child begins to walk, and the muscles are brought into vigorous action, that the arch is fully formed. In the normal foot of the infant, however, there is no valgus, *i.e.*, eversion

or abduction; indeed, the foot naturally assumes a slight tendency towards the varus position, *i.e.*, it is rather adducted than abducted, inverted than everted. The absence of the arch of the foot in the infant does not constitute the condition known as congenital talipes valgus, or flat-foot. Some children, however, never develop a proper instep; the sole remains more or less flat, retaining, so to speak, the infantile form. This condition is described by some authors as congenital splay-foot or flat-foot, as pes planus *sans* valgus, in contradistinction to true congenital valgus, in which abduction as well as slight flattening of the sole is well marked.

### *Congenital or Infantile Pes Planus, or Splay-foot.*

This so-called *congenital pes planus, or splay-foot*, gives rise to little or no inconvenience, but the patient walks in an ungainly manner, with the toes widely turned out, and with a lack of elasticity, as though the elements of the foot were welded together. The foot presents a somewhat similar appearance to that of acquired flat-foot, but there is more of a true sinking of the arch and less of rotation of the bones anterior and posterior to the medio-tarsal joint. In this condition it is said that the os calcis is small and atrophied, and its tuberosities ill developed and directed inwards, and that the head of the astragalus is depressed on its outer side, whilst the scaphoid and the cuboid are rotated inwards on their antero-posterior axis. The ligaments of the tarsus are further said to be relaxed (Rédard). We have no observations of our own on the state of the bones. By some authors this form of so-called congenital flat-foot or splay-foot is spoken of as *infantile flat-foot*, in contradistinction to the true congenital form of talipes valgus, and not without reason, seeing that the deformity can hardly be said to be congenital, in that it is due to an arrest, so to speak, in the development of the natural arching of the foot at the proper period, namely, about the time that the child begins to walk. Between splay-foot as thus described, and a foot with a good instep, and consequently a well-developed arch, all gradations are met with, and it may be somewhat difficult to say whether a given case should be looked upon as one merely of low instep or as one of splay-foot.

Although splay-foot as a rule gives rise to no pain or inconvenience, it is well to correct the condition, since it undoubtedly predisposes to the graver deformity of true acquired static flat-foot as the patient grows older, besides being in itself an ungainly feature.

The *treatment* is similar to that for mild cases of acquired flat-foot. The exercises described under that head should be sedulously carried out, so as to bring the muscles that produce and sustain the arch of the foot fully into play.

### *Congenital Talipes Valgus.*

Under the term *congenital talipes valgus* some German and French authorities describe calcaneo-valgus, and Mr. Adams, although he says he has met with cases of congenital valgus in which there has been neither elevation nor depression of the tuberosity of the os calcis, states that either one or the other may be present. In fact, he describes congenital equino-valgus and calcaneo-valgus along with pure valgus under the head of congenital valgus or congenital flat-foot.

When valgus is associated with depression of the os calcis, that is, with elongation of the tendo Achillis, we prefer to class the condition as a modification of calcaneus rather than as a modification of valgus, and it will be found described under the head of calcaneo-valgus. With regard to valgus with elevation of the tuberosity of the os calcis, we think there is a class of cases in which this condition may be looked upon, as is done by Mr. Adams, as merely a variety of valgus ; but at the same time we hold that there is another class of cases in which elevation of the heel in association with valgus may be better called equino-valgus. In the latter class the equinus is certainly the most marked feature, the valgus position being as clearly superadded. Such cases are described by us under the head of equino-valgus (p. 321). In the former class, although there is elevation of the tuberosity of the os calcis, there is no appearance of equinus ; indeed, the anterior part of the foot is elevated as well as everted, so that at first sight the case appears to be one of calcaneus rather than of equinus. This class is described here with pure valgus, in which there is neither elevation nor depression of the heel.

The existence of pure congenital talipes valgus, or congenital flat-foot, is denied by some authors. It does, however, though rarely, undoubtedly occur. In outward form the foot resembles the acquired variety: the sole is flat, the anterior part of the foot abducted and everted; the inner edge depressed and convex, and the outer edge somewhat raised; whilst the scaphoid and head of the astragalus form prominent projections on the inner border of the foot.

We have had no opportunity of examining post-mortem the condition of the bones, but we should imagine, from the clinical appearances of the feet we have seen with this deformity, that the changes are similar to those in the acquired affection. Nor do the observations of others help us much, since, as far as we can understand them, their descriptions have been taken for the most part from what we regard as cases of calcaneo-valgus or equino-valgus. Thus, it is said that the tuberosity of the os calcis may be depressed or markedly elevated, sometimes as much even as in congenital varus, but such descriptions evidently refer respectively to cases of calcaneo-valgus and equino-valgus. Rédard states that the **Os Calcis** has been found rotated on its anterior posterior axis, so that it lies with its anterior end looking forwards and inwards, and with its concave internal surface looking downwards. In some specimens there has been found, as in the advanced degrees of the acquired deformity, an articulation between the outer surface of the os calcis and the external malleolus of the fibula. In those cases in which the tuberosity of the os calcis is raised, the bone apparently lies with its long axis directed downwards as well as inwards. The **Astragalus** presents few alterations, but its head is more prominent than normal on the inner border of the foot. The **Scaphoid** is rotated so that its tuberosity points to the ground, whilst the whole bone is displaced upwards and outwards. The **Cuboid** is displaced outwards, and its external surface is raised. The **Metatarsal Bones** follow the other bones in their displacement, the internal being in contact with the ground, the external elevated.

**The Ligaments** are elongated on the inner side of the foot, and contracted on the external and inferior aspect.

**The Muscles.**—The peronei and dorsal flexor muscles have been found contracted and tense.

**The Etiology** of the affection, like that of the other congenital deformities of the foot, has been the subject of dispute, some looking upon the deformity as due to spasmodic contraction of the muscles, others as due to malposition or to abnormal compression *in utero*, and others, again, to inherent developmental defects in the germ. These various theories are discussed under congenital varus and congenital calcaneus (pp. 68 and 341).

**The Treatment** is similar to that employed in the acquired deformity, which see.

## Congenital Malformations that may be associated with Congenital Talipes Valgus.

1. *Absence, Complete or Partial, of the Fibula.*—In this condition which is usually associated with the absence of one or more toes, generally the fourth and fifth, the tibia is curved forwards and inwards in its lower third, and over this convexity the skin is depressed, forming a cicatrix adherent to the bone. The tibia, moreover, is usually shorter than the opposite tibia, and the muscles are wasted. The foot is in the position of valgus or equino-valgus, in which position it may be rigidly fixed. The deformity is usually unilateral, and the growth subsequently of the leg below the knee is less than on the sound side.

In a case of this character, watched by Mr. Adams, the shortening, as the patient grew, became extreme. A good example of valgus with absence of the fibula and of the fourth and fifth toes, and a further account of absence of the fibula will be found in the section on deformity of the toes. A dissection of the leg and foot in this condition is figured by Kirmisson in the *Revue d'Orthopédie* for July, 1891.

2. *Defective Development of the External Malleolus.*—This is a well-recognised malformation in conjunction with talipes valgus. A good example of it in a boy was recently under Mr. Walsham's care in the hospital. The external malleolus in these cases can only with difficulty be felt, and is apparently small and ill developed. The internal malleolus stands out more prominently than usual, and often appears enlarged. The foot is usually rigidly fixed in a position of extreme valgus, so that the sole looks directly outwards, and the inner edge downwards. The tuberosity of the

os calcis is not raised, and the front part of the foot is not drawn up. In our case the deformity could not be reduced on the division of the peronei and tendo Achillis. The foot in itself appeared natural, and the arch was very little, if at all, flattened. Mr. Adams thinks that in some of these cases the fibula may be fused with the tibia. Like him, however, we have had no opportunity of verifying the state of the parts by dissection. The removal of a wedge-shaped piece of bone from the internal malleolus without opening the ankle-joint immensely improved Mr. Walsham's patient. The sole could now be placed on the ground and the foot used in walking.

3. *Defective Length of the Leg.*—In some instances of valgus, the leg below the knee may be an inch or so shorter than the opposite leg. In the cases seen by Mr. Adams, the foot was not rigidly held in the valgus position, and the eversion was only slight.

4. *Increase in the Length of the Leg.*—We have seen one example of this condition. The tibia and fibula were about two inches longer than the bones of the opposite limb ; the foot was in a marked valgus position and could not be corrected by tenotomy. The position was somewhat improved by an osteotomy of the tibia. Mr. Adams has seen elongation of the leg in association with valgus deformity of the foot, but in his case the whole limb was the subject of congenital hypertrophy. In our case the limb, except that the tibia and fibula were longer than on the opposite side, was normal.

5. *Rotation of the Leg at the Knee-joint.*—An example of this is described by Mr. Adams. The leg was so rotated that* 'the heel was brought directly in front whilst the foot was directed backwards.'

6. *Deficient Growth of both Legs, with Malformation of the Knee and Ankle Joint.*—Examples of these deformities in association with valgus are related by Mr. Adams in the Appendix of his book on 'Club-foot.'

* Adams, 'Club-foot,' 1873, p. 320.

### Acquired Talipes Valgus, or Flat-foot.

Acquired flat-foot is exceedingly common. There are many varieties of the deformity. We shall describe in the first place the typical form due to long standing or weight-bearing (*static flat-foot*), and then point out the peculiarities of the other and less common forms in the section on Varieties. The etiology, morbid anatomy, and treatment will also have special reference to this form.

**Description of Static Flat-foot.**—The ordinary static flat-foot presents well-marked appearances. The arch is more or less

FIG. 238.—A TYPICAL CASE OF ACQUIRED FLAT-FOOT. (From a photograph taken in the Orthopædic Department of St. Bartholomew's Hospital.)

The left foot viewed from the inner side shows the depression of the inner edge of the foot, and a straight great toe. The right foot seen from the outer side is 'flattened' on the dorsum, and exhibits a concavity at the outer ankle.

lost, the inner edge is depressed, the outer edge slightly raised, and the anterior portion abducted at the transverse tarsal and sub-astragaloid joints.

The foot, being deprived of its chief attribute of comeliness—a good instep—presents an ungainly appearance, and upon comparing a medium case of flat-foot with a normal foot, the chief characteristics of the morbid condition are at once apparent. A complete transformation is effected in the region of the medio-tarsal joint, owing to the displacement of the several bones. The

dorsum is flattened, and a straight edge or an ill-shapen convexity takes the place of the upward curve of the instep on the inner side, being most marked about the centre of the tarsus. The hallux (Fig. 239) is generally in the position of valgus (a condition which probably preceded the flat-foot), with the consequent changes about the metatarso-phalangeal joint. But besides the changes due to the hallux valgus, there is a diminution in the ball of the great toe, and a consequent upraising of the

FIG. 239.—A SEVERE CASE OF FLAT-FOOT VIEWED FROM THE FRONT. (From a photograph taken in the Orthopædic Department, St. Bartholomew's Hospital.)

There is extreme flattening of the dorsum, a deep concavity on the outer side of the ankle, and marked valgus of the ankle. The great toe is to some extent beneath the second, in a condition of slight hallux valgus.

bones entering into the joint on the dorsal surface (Fig. 241). This is due to a depression of the base of the first metatarsal bone, as will be explained further in the section on pathology.

The great toe, when at rest, is in a position of slight dorsal flexion, but owing to the above change at the metatarso-

FIG. 240.—ADVANCED FLAT-FOOT, SHOWING THE 'FLATNESS' OF THE DORSUM WITH ABDUCTION OF THE FRONT PART OF THE FOOT. (From a photograph taken in the Orthopædic Department of St. Bartholomew's Hospital.)

FIG. 241.—MEDIUM FLAT-FOOT, SHOWING MARKED HALLUX FLEXUS. (From a photograph taken in the Orthopædic Department of St. Bartholomew's Hospital by Mr. Griffiths.)

phalangeal joint, it becomes horizontal, or even slightly plantar-flexed; and its plane of movement being from above downwards and inwards, it will be less abducted than at first.

Owing to the depression of the tarsal bones, the foot is increased in length (Fig. 238) and breadth (Fig. 239)—more especially the former; the increase in length occurs only on the inner side, the outer edge, on the contrary, being slightly

Fig. 242.—Flat-foot in a Moderate Degree, seen from Below. (From a photograph taken in the Orthopædic Department of St. Bartholomew's Hospital.)

diminished. This is merely an exaggeration of the change that takes place in a normal foot upon abduction (p. 25).

The increase in the length of the inner edge is due to the depression of the astragalus, and to a lesser extent to the depression of the scaphoid and internal cuneiform bones, which thus push the inner metatarsal bones forwards and the heel backwards.

The inner metatarsal bones, being propelled directly forwards by the *vis a tergo* supplied by the sinking arch, and being held

laterally by reason of their connections with the outer bones of the tarsus and outer metatarsal bones, take a resultant direction, and give the anterior part of the foot an appearance of abduction at the medio-tarsal joints.

The inner border is on the same plane, or even on a lower plane, than the outer, and is easily divisible into two parts, one anterior, and the other posterior, to Chopart's joint. Thus, the head of the astragalus forms the most prominent point on this border. Proceeding forwards from the prominent astragalus, the inner border gradually runs slightly outwards, often terminating in a marked hallux valgus (Fig. 247); proceeding back-

FIG. 243.—FAIRLY-ADVANCED FLAT-FOOT. (From a photograph taken in the Orthopædic Department, St. Bartholomew's Hospital, by Mr. Clindening.)

The relative positions of the internal malleolus, head of astragalus, and tubercle of scaphoid, are shown by three black dots. The line joining these three points is convex downwards and backwards, whereas in a normal foot with a good arch it is convex upwards and forwards. The great toe is in a state of slight plantar flexion, the normal condition being that of slight dorsal flexion.

wards from the same point, the inner border runs rather sharply outwards to the heel owing to the obliquity of the os calcis.

On the lower part of the convex inner border of the foot may be seen two prominences, the enlarged tubercle of the scaphoid and the head of the astragalus (Fig. 243), the prominences being due partly to displacement of the bones, and partly to enlarge-

ment from chronic periostitis and osteitis, the result of pressure. These prominences are sometimes almost fused together, so as to

FIG. 244.—FLAT-FOOT FROM BEHIND, SHOWING THE OBLIQUE POSITION OF THE OS CALCIS AS REGARDS THE LINE OF THE LEG, ESPECIALLY ON THE RIGHT SIDE. (From a photograph taken in the Orthopædic Department of St. Bartholomew's Hospital.)

There is also marked valgus on both sides, and eversion of the sole, especially on the left side, where the outer edge of the foot is quite raised off the ground.

FIG. 245.—FLAT-FOOT (RIGHT) FROM THE OUTER SIDE, SHOWING SLIGHT EVERSION OF THE OUTER EDGE AND FLATTENING OF THE DORSUM. (From a photograph taken in the Orthopædic Department of St. Bartholomew's Hospital.)

give the appearance of a single prominence, but with a little care a groove between them can always be detected with the finger.

The skin over the lower part of this convexity is thickened, and in some cases there is a subcutaneous bursa over the head of the astragalus—more rarely over the tubercle of the scaphoid. Behind these prominences, and on a slightly higher level, a larger but flatter nodule of bone is occasionally met with—namely, the inner surface of the astragalus, which has been rendered more prominent by chronic periostitis the result of friction. In slight cases the internal malleolus may appear natural, but in severe

FIG. 246.—PHOTOGRAPH TO SHOW FLATTENING OF THE SOLE IN A MODERATELY SEVERE DEGREE OF FLAT-FOOT. (Taken in the Orthopædic Department, St. Bartholomew's Hospital.)

cases it is very prominent and somewhat displaced inwards, and is nearer the ground than normal. The skin over it may be thickened and a subcutaneous bursa may be sometimes present. In all cases of flat-foot, owing to the sinking of the astragalus, the internal malleolus is nearer to the ground than normal, but when the arch has altogether given way, and the patient walks almost entirely on the inner edge of the then abducted foot—the outer

edge being raised off the ground—the internal malleolus, owing to the weight of the body being transmitted more directly inwards, descends still further downwards and inwards. The ankle thus assumes a well-marked valgus condition, a condition (Fig. 244) which in some cases may precede the flat-foot, but is always aggravated as the arch sinks.

The astragalus, carrying the anterior part of the os calcis downwards and inwards, rotates the latter bone upon an oblique diameter so that its outer edge is raised and the posterior portion of the bone is carried outwards. This obliquity of the calcis is

Fig. 247.—Photograph of Casts of the Feet of a Young Man, showing Extreme Flatness of Sole with a Well-marked Bulging of the Inner Edge, the Inner Edge being represented by a Curved Line with Convexity inwards, the Outer Edge by a Curved Line with Concavity outwards. (From St. Bartholomew's Hospital Museum.)

perhaps the most marked feature in flat-foot, and its alteration in position may be considerable—even in those cases in which the diminution in the convexity of the arch is but slight.

The depression of the instep causes a flattening of the dorsum on the inner side, and, according to the severity of the case and consequent valgus position of the ankle, there will be more or less hollowing out of the posterior portion of the outer side of the

dorsum and of the outer side of the ankle (Fig. 245). The tendons of the peroneus longus and brevis will be found in severe cases very tense and strongly contracting (Fig. 245).

The outer edge in slight cases may appear natural, but, as was stated in Chapter I., p. 25, whenever the foot is abducted there is a diminution in the length of the outer edge. In more marked cases, in addition to this diminution in length, the outer edge is everted, and sometimes altogether raised off the ground. The

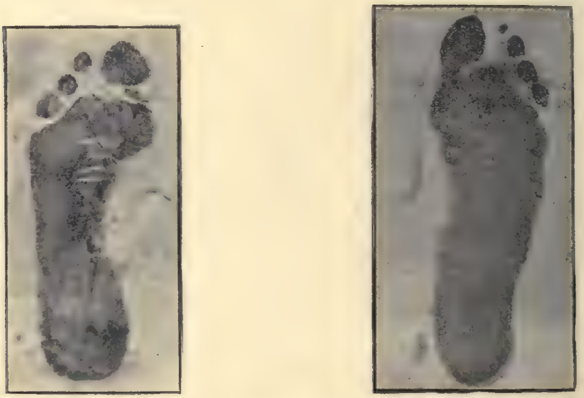
FIG. 248.—FLAT-FOOT OF MEDIUM SEVERITY. (From a photograph taken in the Orthopædic Department of St. Bartholomew's Hospital.)

manner in which this is effected will be discussed at length in the section on pathology.

The sole, deprived of its graceful curves, is reduced to a dead level, and presents a most characteristic appearance of dreary flatness, with, in severe cases, a convex prominence on its inner side (Fig. 247). The amount of abduction at the medio-tarsal joint may be easily estimated by continuing the mid-line of the

under surface of the heel forwards and the mid-line of the under surface of the great toe backwards (or, if there be hallux valgus

FIG. 249.—PHOTOGRAPH OF CAST OF ADVANCED FLAT-FOOT, SHOWING THE ABDUCTION AND EVERSION OF THE ANTERIOR PART OF THE FOOT. (St. Bartholomew's Hospital Museum.)



A B

FIG. 250.—PHOTOGRAPHS OF THE IMPRESSION OF THE SOLE IN A MEDIUM (A) AND A MODERATELY SEVERE (B) DEGREE OF FLAT-FOOT. (Taken with charcoal on blotting-paper.)

in addition to flat-foot, by substituting the space between the great and the second toe for the mid-line of the great toe). In

a normal foot these lines should be in the same straight line, so that the angle formed by them in flat-foot will show the amount of abduction that has taken place (Fig. 248).

Besides the changes of direction in the bones, various bursæ may be found over any or several of the enlarged prominences of bone, as the internal malleolus, head of the astragalus, tubercle of the scaphoid, and beneath the thickened skin over the first metatarso-phalangeal joint. In addition to the bursæ, local puffiness of the subcutaneous tissue, both on the inner and outer side of the ankle, and effusion into the sheaths of the tendons or even into the ankle-joint may occur.

## Etiology of Acquired Flat-foot.

Several varieties of acquired flat-foot may be described, as the rachitic, the rheumatic, the traumatic, and the paralytic. These, as their names imply, depend primarily upon rickets, rheumatism, injury and paralysis respectively, and the way in which, as the result of these several conditions, the flattening of the foot may be brought about will be considered after we have discussed the causation of ordinary acquired static flat-foot—the form most frequently met with, and the form to which our description of flat-foot more generally applies.

**Static Flat-foot**, as commonly seen, is undoubtedly, in by far the greater number of cases, caused by long-standing with the feet in the abducted position, or by excessive weight-bearing; in both instances, as a rule, in subjects who, either on account of rapid growth or of constitutional debility produced in other ways, are defective in muscular and ligamentous tone. But there are probably other conditions which, either in combination with the above, or sometimes possibly alone, are responsible for the deformity, notably, ill-fitting boots, hallux valgus, valgus ankles, congenital defects, as absence of the instep, etc.; whilst spasmodic muscular contraction, weakening of certain muscles, arthritis, past rickets, etc., have been considered the chief factors by some authors. These various conditions will be considered in detail under the following heads:

(1) *Long Standing.*—Persons who have to stand much either adopt the 'attitude of rest' (Annandale), that is to say, stand

with their feet somewhat wide apart, or stand first on one foot and then on the other, in each instance with the feet or foot abducted.

We have shown (Chapter I.) that abduction is the weak position for the foot—adduction, the strong. In the latter case the foot is well braced up by vigorously-acting muscles, especially the flexor longus hallucis and tibialis posticus, the convexity of the arch is at its maximum, and the bones are in the best possible position for resisting the downward and inward pressure of the weight of the body. In abduction, on the other hand, we have seen that the inner edge of the foot is lengthened, that there are no muscles actively contracting, that the muscles on the inner side are stretched beyond their normal limits, and the ligaments are strained to the utmost to keep the bones together. We further pointed out that, when standing with the feet in a position of abduction, the weight of the body instead of being transmitted for the most part to the heel, is largely directed downwards and inwards, towards the fore part of the os calcis, the astragalus bearing down the fore part of the calcis obliquely as well as carrying the scaphoid with it. The strain therefore falls chiefly upon the calcaneo-scaphoid and calcaneo-astragaloid (interosseous) ligaments, which have to resist the inward and downward rotation of the astragalus, being aided only by the impaction of the anterior part of the external malleolar facet against the fore part of the upper surface of the os calcis. Since the scaphoid in abduction is rotated downwards and inwards, the tibialis posticus is carried further downwards, and therefore its action in restraining the inward rotation of the astragalus is diminished to a very large extent, and the inner part of the calcaneo-scaphoid ligament has to bear the whole strain of the inwardly-rotating head of the astragalus excepting in so far as it is held back by the calcaneo-astragaloid (interosseous) ligament.

Ligaments when subjected to a continuous strain soon tend to yield. What happens, then, when we stand for long periods with feet in an abducted position? The astragalus rotates further downwards and inwards, the calcaneo-scaphoid and calcaneo-astragaloid (interosseous) ligaments yield, and the position of abduction becomes aggravated; in other words, 'flat-foot' has begun to develop, flat-foot being a continued aggravated position of abduction. Unless checked by proper direction of

muscular force, this condition is soon increased, and, finally, the head of the astragalus reaches the ground, carrying with it the scaphoid and the sustentaculum tali, the tubercle of the former reaching the ground just anterior to the head of the astragalus, the latter approaching the surface (but only in the most extreme cases) at a point external to it. We thus arrive at the conclusion that those who have to stand for long periods develop flat-foot on account of their adopting a position of abduction; for, in addition to the severe strain imposed by hours of continuous standing, the foot is placed in the position least fitted to bear any superincumbent weight. Since, however, flat-foot does not occur in everyone who stands long or walks badly, it would appear that there are certain prior conditions which favour its development, and these are chiefly to be sought in such as induce defective muscular, and probably defective ligamentous, tone, and will be discussed under the heads of rapid growth, convalescence from acute illness, etc.

(2) *Excessive Weight-bearing.*—Those who carry heavy weights, as bricklayers' labourers, coal-porters, housemaids, and errand boys, are frequent sufferers from flat-foot.

In such the muscles and ligaments have to support heavy weights in addition to the weight of the body, and, proving unequal to the task, give way. In some of these patients there may be, and undoubtedly there often is, some predisposing cause present, such as one of those referred to above; but in others there is no evidence of any want of tone about the muscles or ligaments, and we must assume, that although these structures may have sufficient strength to resist the pressure of the ordinary weight of the body, yet they yield before the extra burden thrown upon them when excessive weights are carried.

The yielding of the ligaments is, no doubt, further brought about by faulty positions in standing and walking, positions assumed to rest the over-burdened muscles.

(3) *Ill-fitting and Improperly-shaped Boots.*—Boots are probably responsible for some cases of flat-foot, and may be looked upon sometimes as a predisposing, and sometimes as an exciting, cause. The fashionable median pointed boot, in that (as we believe) it frequently produces hallux valgus, may be regarded as a predisposing cause.

The heavy, thick, and ungainly boot worn by the labouring classes, since it has little tendency to give at any point in response to the natural movements of the foot, prevents the foot from acting as a living elastic mechanism, and rather reduces it to a solid encumbrance at the end of the leg. The boot being heavy and unyielding, and the muscles of the foot, in consequence, not being free to act, the wearers walk with the feet markedly abducted, and so hasten the production of flat-foot.

FIG. 251.—INCIPIENT FLAT-FOOT (RIGHT SIDE): RIGHT-ANGLED TALIPES OF THE LEFT FOOT WITH CAVUS AND CLAWED TOES, AND HALLUX VALGUS BOTH SIDES. (From a photograph taken in the Orthopædic Department of St. Bartholomew's Hospital.)

While under treatment for the left foot the right foot became flat.

The not infrequent occurrence of flat-foot in constables and soldiers is probably in part to be attributed to the regulation pattern of boot which is served out to them, irrespective of the shape of the individual foot. But the manner in which they have been drilled to stand and march, with the toes turned out, with

the feet in the abducted position, has probably as much to do with it.

(4) *Inequality in the Length of a Lower Limb, or Disablement of One Foot or Lower Limb.*—These conditions have the effect of giving the other foot an extra amount of weight to bear, and if there be any predisposition to flat-foot, that deformity will quickly develop. (Fig. 251.)

Examples of this cause are constantly met with amongst patients with a shortened limb the result of hip disease, infantile paralysis, fracture, etc.

(5) *Valgus Ankles.*—Flat-foot very frequently occurs in children of two or three years of age, being preceded by a valgus condition of the ankles. At first, if these children be taken off their feet, the arch is restored; but if they are allowed to run about, the ligaments soon become stretched, and do not recover when relieved of pressure. Many of these cases are rickety, or have a distinctly rickety history, or are weakly and ill nourished, and exhibit a marked lack of muscular and ligamentous tone. The valgus condition of the ankle allows the weight of the body to be transmitted too much to the inner side of the foot, and the extra pressure on the arch causes it gradually to yield.

(6) *Rapid Growth* is, perhaps, one of the commonest predisposing causes of flat-foot. Turning to our statistics, and to those of others, we find that flat-foot is most frequent between the ages of twelve and eighteen. At this period many boys and girls grow rapidly, and their tissues, spending their energy in production, have little to spare to meet any extra exertion called for by vicious attitudes in standing and walking, excessive weight-bearing, etc. As further evidence of the general want of muscular and ligamentous tone in these quick growers, we may call attention to the poor development of the calf muscles, and to the frequency with which knock-knee and lateral curvature of the spine are also developed.

(7) *Deprivation of Muscular Action* would appear to be another frequent cause of flat-foot. A general deprivation of muscular action may be said to occur whenever the subject stands with the feet in the abducted position, or wears such boots as impede the free movement of the muscles of the foot. These conditions have been already discussed; but the deprivation

of the action of certain special muscles is also believed to play an important part in the production of flat-foot. Thus, the deformity is attributed to (*a*) the deprivation of the action of the long plantar flexor of the great toe, consequent upon a valgus condition of that digit (*hallux valgus*); (*b*) to a weakness of the peroneus longus, or of the tibialis anticus.

(*a*) *Hallux Valgus.*—As we mentioned in our introductory chapter, it has been clearly pointed out by Mr. Ellis that the long plantar flexor of the hallux is an important factor in maintaining the plantar arch, acting, as he puts it, 'like the bowstring to a bow,' and as it contracts increasing the convexity of the arch. Its line of action in a normal foot (see page 37) corresponds with a straight line drawn through the mid-point of the heel and through the middle line of the great toe. If, however, the great toe be in a position of marked valgus, the line of action of the tendon is altered, and instead of strongly maintaining and supporting the convexity of the arch, it does so but feebly, and, moreover, tends to increase the valgus of the great toe, and thus further weakens its own action upon the arch.

(*b*) *Weakness of the Peroneus Longus or of the Tibialis Anticus.*—Weakness of the peroneus longus has been urged by Duchenne of Boulogne, and weakness of the tibialis anticus by Sayre, as respectively the chief, if not the sole, cause of flat-foot. In neither case, however, has any reason been assigned for such weakness. In the case of the long plantar flexor of the hallux, there is no need to assume that the muscle is weaker than any of the other muscles of the foot, its altered line of action consequent upon the valgus position of the great toe being sufficient to deprive the arch of the foot of the support which it normally receives from this tendon.

With regard to the question of *weakness of the peroneus longus*, it appears to us that, assuming this muscle to be weak, or even paralyzed, flat-foot would not necessarily follow. In cases of infantile paralysis with weakened peronei, the muscles on the inner side of the foot being to a great extent deprived of their opponents exert their inverting power, and draw the foot into a position of varus, rather than let it drop into one of valgus. Further, we have had many cases of flat-foot under our care in which the peroneus longus has been tested, and has acted readily and more strongly

than the other muscles of the foot; but then we must remember that its contractions are especially readily elicited by electric stimulation. No doubt a weakened action of the peroneus longus may sometimes be met with in flat-foot, for the reason that not only are the muscles generally weak in this condition, but because the peroneus has to act at a disadvantage when the foot is abducted, owing to its attachments being approximated. More often, however, we have found the peroneus longus in a state of spastic contraction, since, owing to the adductor muscles being put (in consequence of the abducted position of the foot) almost out of court, it endeavours to take upon itself too great a share in elevating the posterior part of the foot, thus leading at last to spastic contraction and adaptive shortening, a condition which is only relieved by rectifying the deformity and not by attempts at strengthening the muscle by galvanism or other means.

As to the question of *weakness of the tibialis anticus* being a cause of flat-foot, it should be remembered that this muscle is only one of the supporters of the arch, and when it is acting most strongly it is occupied in drawing the leg forwards, using its attachment to the foot as a fixed point, which fixed point must be supported by the action of other muscles. We have never detected any special weakness of this muscle ourselves, and Mr. Golding Bird* says that he has diligently searched for such weakness in a large number of cases of flat-foot, but has never been able to satisfy himself of its presence.

(8) *Paralysis of the Tibial Muscles.*—Paralysis of the tibialis anticus, or of both the tibialis anticus and posticus, as the result of infantile paralysis, is an occasional cause of talipes valgus. In consequence of the loss of power in these muscles, the foot becomes abducted and the arch sinks, whilst the peronei on the outer side become spastically contracted and hold the foot in the deformed position.

(9) *Contraction of Muscles.*—Some authors attribute flat-foot to muscular contraction. Thus, it has been ascribed to contraction of the tendo Achillis, contraction of the peronei, etc. Both the tendo Achillis and the peronei may be found contracted, but we maintain that such contraction is the result, not the cause, of the affection.

* 'Guy's Hospital Reports,' vol. ii., 1882.

(10) *Congenital Malformation of the Bones* is regarded by some authors as an essential cause of flat-foot. We have never detected such a congenital defect ourselves in early cases. In those advanced cases in which alteration in the shape of the bones has been found, the alteration is clearly the result, not the cause, of the affection.

(11) *Rheumatic Fever* is a common precursor of flat-foot. From our statistics we find that out of 1,078 cases of flat-foot there was in 95 a distinct history of flat-foot coming on during convalescence from it. Though flat-foot occurring after rheumatic fever may partly be accounted for by the constitutional weakness that ensues after any acute illness, we have a more direct explanation in the fact that in rheumatic fever the fibrous tissues are especially attacked, and that they might therefore be expected to be liable to stretch as the patient begins to walk.

Flat-foot is certainly more common after rheumatic fever than during convalescence from other acute diseases.

(12) *Traumatism.*—Injury to ligaments or muscles may be either a predisposing or an exciting cause. In many instances such an injury is essentially a predisposing cause, in that it merely consists in some strain whereby the resisting power of the ligaments or muscles is weakened, so that flat-foot ultimately develops. In other instances the injury is evidently an exciting cause, in that it may consist in an actual rupture of some of the supporting ligaments and muscles, so that at the time of the injury the bones are actually displaced or are allowed to become displaced as soon as the patient puts any weight upon his foot. In the case of a strain the relation between such and the flat-foot is no doubt sometimes an imaginary one on the part of the patient; but frequently the flat-foot follows so soon that the connection seems obvious. It is not necessary to assume that any one ligament or set of muscles should be thrown out of action to produce flat-foot, for all the muscles and ligaments act together in harmony to maintain the mechanism of the foot, and if one set is injured or weakened the rest have an extra burden thrown upon them, and are thus more liable to yield.

Under the head of traumatism may be further mentioned those cases of flat-foot which follow an old injury about the ankle, such as a badly-set Pott's fracture. Here the flattening of the foot is

in part due to the actual displacement of the bones, which has not been rectified, and in part to the weight, in consequence of the non-rectification, being thrown too much on the inner side of the foot and thus causing the arch to yield (see Traumatic Flat-foot).

(13) *Cicatrices of Burns or Large Wounds on the Instep* have led to a condition similar to that met with in static flat-foot, but cases of flat-foot following such conditions are merely surgical curiosities, and need not be further discussed.

(14) *Rickets* is a very common cause of flat-foot in young children. The way in which the flattening is brought about is discussed under the head of rickety flat-foot.

(15) *Locomotor Ataxy.*—Gowers points out that flat-foot is comparatively common in locomotor ataxy, partly because of the impairment of muscular tone, and partly because of the faulty method of walking. In these patients we have to deal with a new mode of progression: the heel comes down with a sharp rap, and thus tends to throw the posterior part of the os calcis upwards and the anterior end downwards. This leads to sinking of the astragalus, and the weight of the body being thus directed more downwards and inwards than normally, flattening of the foot is produced.

## CHAPTER XI.

### PATHOLOGICAL ANATOMY OF FLAT-FOOT.

In the earlier stages of ordinary static flat-foot, beyond a slight sinking of the bones forming the plantar arch, and an exaggeration of the position which the bones assume in extreme abduction (see p. 25), there is little alteration in the skeleton of the foot. The bones are not altered in shape, and save some elongation or stretching, and, perhaps, slight thickening of certain of the tarsal ligaments, there is no marked change in the tarsal articulations. On adducting the foot, moreover, and pressing upwards the bones forming its inner border, the flattening disappears, and its shape is more or less completely restored. But in the later stages of the affection, and especially in severe and intractable grades, great alterations occur not only in the relations of the tarsal bones to each other, but also in the shape of the bones themselves. Certain of the ligaments, too, are stretched and elongated; others are shortened and contracted; whilst some of the muscles undergo adaptive shortening, and so further help to hold the bones in their displaced position.

The alterations in the bones, ligaments and muscles will be first considered in detail, and then a general description will be added of the skeleton of the foot as a whole.

**Alterations in the Bones.**—Briefly put, the alterations in the relations of the bones may be said to be a general sinking of the semi-dome or arches of the foot, with abduction of the foot, especially at the transverse tarsal and subastragaloid joints, and a general rotation inwards of all the bones on their antero-posterior axes. The alterations in shape of the bones, which will be described presently in detail, are such as we should expect to find in bones subjected to this alteration in relation to one another,

and are brought about in part by atrophy from pressure, and in part by new growth of bone, for the purpose, it would appear, of limiting the continuous displacement. The changes are well said to be of such a kind as to prevent rather than to favour a further increase in the deformity.

The following description of the bones in severe cases of flat-foot is based in part on the observations of Lorenz, Hoffa, and Rédard, but chiefly on a specimen obtained for us by Mr. Berry from the Post-mortem Room, and now in St. Bartholomew's Hospital Museum (Figs. 252, 253).

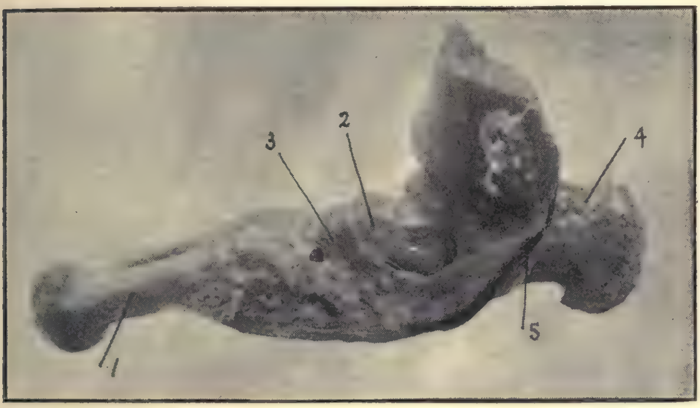



FIG. 252.—PHOTOGRAPH OF THE SKELETON OF A FLAT-FOOT (SEVERE GRADE).

1. Original dorsal surface of the first metatarsal bone. 2. Heaping up of bone on the articular surface of the head of the astragalus. Part of the articular surface of the astragalus is seen to project from the ankle-joint. 3. The scaphoid. 4. The os calcis displaced much to the outer side. 5. The tendon of the tibialis posticus running beneath the head of the astragalus to the scaphoid, instead of, as normally, on the inner side of the head of the astragalus.

**The Astragalus** is said to be displaced downwards and inwards, that is, partially tilted out of the socket formed for it by the bones of the leg. As a result of this, it is further said that the anterior fourth or third of the trochlear surface is denuded of cartilage. Viewed in its relations to the remaining bones of the tarsus, the astragalus is certainly displaced in a downward, forward and inward direction, but we have been unable to convince ourselves

that it undergoes, except in very advanced cases, much tilting out of its socket. Its relation to the leg bones is undoubtedly altered. Thus, while slightly plantar-flexed it is in a position, or, rather, an exaggerated position, of abduction. The external malleolus is on a plane anterior to the internal malleolus; the external cartilaginous facet is denuded of cartilage in its posterior half, and the internal articular facet is prolonged somewhat backwards. The anterior edge of the trochlear surface, instead of extending further forwards on the inner aspect of the bone, as in the normal astragalus, extends further forwards on the outer side, so that the plane in which this border lies is directed forwards and inwards, instead of forwards, or forwards and outwards, as in the normal bone. The cartilage has not been removed evenly, as commonly described, from the anterior fourth of the trochlear surface, but obliquely, leaving a triangular-shaped denuded portion of bone at the front of the superior trochlear surface, with its base looking inwards. Further, the posterior border of the trochlear surface lies in a plane looking also forwards and inwards, *i.e.*, in a plane parallel to the plane of the anterior border, instead of directly forwards as normally, the articular surface internally being prolonged nearly to the posterior edge of the bone.

As regards, then, its relation to the leg bones, the astragalus is displaced downwards and outwards—not downwards and inwards, as usually described. It has, in fact, shared in the abduction of the other bones, the apparent inward displacement being due to the abduction of the remaining tarsal bones at the subastragaloid and transverse tarsal joints. The amount of tilting of the astragalus out of its socket, however, no doubt varies, since Rédard states that the anterior third of the trochlear surface has been found completely, and the middle third partially, denuded of cartilage.

The *rounded facet* on the head of the bone for articulation with the scaphoid and calcaneo-scaphoid ligament has been found in correspondence with the displacement of the scaphoid to present certain alterations. Thus, the facet for the calcaneo-scaphoid ligament is increased in size, the head of the astragalus resting in chief part upon the elongated calcaneo-scaphoid ligament; whilst the normal facet for the scaphoid is to a like extent diminished. At the upper and outer part of the head new bone has been found

heaped up, and upon the surface of this new bone the normal scaphoidal facet is prolonged, the surface of the new bone being covered by fibro-cartilage. This new formation of bone appears to have for its purpose the prevention of the further dislocation of the scaphoid upon the astragalus. The scaphoidal surface on the new bone, in place of being convex forwards, is concave, so that the scaphoidal facet as a whole is concavo-convex, instead of convex. In some cases where the new formation has been absent, or less marked, the scaphoid has been completely dislocated upwards on to the astragaloid neck.

Fig. 253.—Photograph of the Skeleton of a Flat-foot (Severe Grade) taken from the Outer Side. (St. Bartholomew's Hospital Museum.)

The head and neck of a normal astragalus is usually described as forming a right angle with the body of the bone, the direction of the neck, as a whole, being slightly inwards. Although in the normal bone the general direction of the neck is undoubtedly slightly inwards, yet when the mid-line of the trochlear surface is prolonged on to it, the neck itself at the same time is seen to make a distinct twist outwards. In our specimen of flat-foot the outward twist of the inwardly deflected neck is most marked. Partly in consequence of this exaggerated twist of the neck, and partly on account of the great heaping up of new bone on the

upper and outer side of the head, the outer portion of the head is external to, and on a higher level than, the anterior external angle of the trochlear surface. Thus, though the head of the astragalus appears depressed, and rotated inwards, yet the upper and outer portion, especially of that part newly formed, seems to follow the general line of the abducted tarsal bones.

*The external articular facet* is completely denuded of cartilage at its posterior part, the cartilage-covered surface thus forming a scalene instead of an almost equilateral triangle, as in the normal bone.

*The internal articular facet* is prolonged backwards to the groove for the flexor longus hallucis, and its surface, instead of looking, as normal, almost directly inwards, looks upwards as well as inwards, and the ridge between it and the superior surface of the bone is in consequence much less sharp than usual. The anterior or broader part is denuded of cartilage for about a quarter of an inch ; and the posterior part, instead of tapering off as a narrow tail-like extremity, as in the normal condition, remains almost as broad as the anterior. This surface as a whole, in place of being flat, slightly concave, or very slightly convex from before backwards, is distinctly convex.

On the *under surface* of the bone the *postero-external articular facet*, with the exception that it is somewhat less concave than normal, presents nothing noticeable. In front, and to the external part of this surface, on the rough portion of bone which forms in the normal foot the upper and posterior boundary of the interosseous canal, a *new facet* is formed, with its surface looking downwards, forwards, and outwards. This facet articulates with a similar new facet on that portion of the os calcis which normally forms the floor of the interosseous groove, and lies internal to the three nutrient foramina so constantly found on this surface. The anterior end of the interosseous groove, instead of being situated over the anterior end of the os calcis, is shunted inwards. The smaller anterior articular facet on the under surface of the head of the bone is narrower than usual. On the anterior and inner edge of the larger posterior or external articular facet is a distinct cartilage-covered ridge, articulating with the sustentaculum tali, and thus forcing the interosseous ligament out of its groove and on to the ridge bounding the articular surface of that

process. This ridge tends to prevent the astragalus being further displaced in a forward and inward direction on the os calcis.

**The Os Calcis.**—Broadly put, the displacement of the os calcis from the astragalus may be said to be that which the bone occupies in extreme abduction, but, of course, greatly exaggerated. Thus, as in abduction of the foot, the os calcis so glides and rotates upon the astragalus that, whilst its outer border, with the

A B

FIG. 254.—PHOTOGRAPH OF THE LEG BONES, WITH THE ASTRAGALUS AND OS CALCIS, (A) IN A NORMAL FOOT, AND (B) IN FLAT-FOOT (FROM BEHIND). (Taken from specimens in St. Bartholomew's Hospital Museum.)

outer border of the foot, is raised, its anterior end, with the rest of the foot, is rotated outwards; whilst its tuberosity is to a less extent, as the shorter arm of the lever, rotated inwards. In addition to this displacement, the anterior end of the os calcis is depressed along with the other bones forming the arch of the foot. Thus, the os calcis lies rotated on its antero-posterior axis,

so that its outer border looks upwards as well as outwards, and its inner border downwards as well as inwards, whilst its external tuberosity is raised three-quarters of an inch or more from the ground. Its anterior end, instead of looking directly forwards, in consequence of the rotation on the vertical axis, looks forwards and outwards, and lies altogether external to the astragaloid head. As a further consequence of this rotation, the upper border of the articular surface of the depressed anterior end lies in almost the same horizontal plane as the upper border of the astragalus, instead of, as in the normal bone, in a plane considerably below it. In our specimen, the displacement of the os calcis, in the direction above described, is so extreme that it is in great part dislocated in an outward and backward direction from the astragalus, and lies almost entirely beneath the fibula, with the end of which it articulates (Fig. 254).

The relation of the os calcis to the other bones of the tarsus is not materially altered.

The *chief changes in the shape of the bone* may be said to be (1), an alteration in the astragaloid articular surfaces, which, in consequence of their gradual moulding to accommodate themselves to the more and more abducted position, have become shunted, so to speak, in a forward and inward direction towards the inner side of the bone ; and (2) the formation of new articular facets, where, in consequence of its displacement, the bone has come into contact with a portion of bone, and a bone, not normally in contact with it, namely, the anterior and lower part of the external triangular articular facet of the astragalus, and the tip of the external malleolus of the fibula (Fig. 255).

The *postero-external articular facet* for the astragalus, in consequence of the displacement of the astragalus on the os calcis in a forward and inward direction, is itself displaced forwards and inwards, reaching across the interosseous groove to the sustentaculum tali. It no longer presents the sharp ridge on its external border seen in the normal bone, but is bounded by an irregular denuded ridge of bone. This ridge was evidently a former portion of the articular facet (Fig. 254).

The *antero-internal facet* on the sustentaculum tali has been found greatly reduced in size, the greater portion of the sustentaculum tali itself corresponding to the interosseus groove on the

astragalus. The articular surface on the astragalus, which normally articulates with the facet on the sustentaculum tali, is displaced with the head of the astragalus forwards and inwards, and rests upon the calcaneo-scaphoid ligament. The non-articular portion of the os calcis in front of the facets is hollowed out, and the inferior angle of the triangular external surface of the astragalus rests in it, forming here a new articular facet. The position of this facet varies with the degree of the flat-foot. In slight cases it lies, as pointed out by Rédard, external to the three nutrient foramina, constantly seen on this part of the bone, but in severe cases internal to these foramina. In such severe

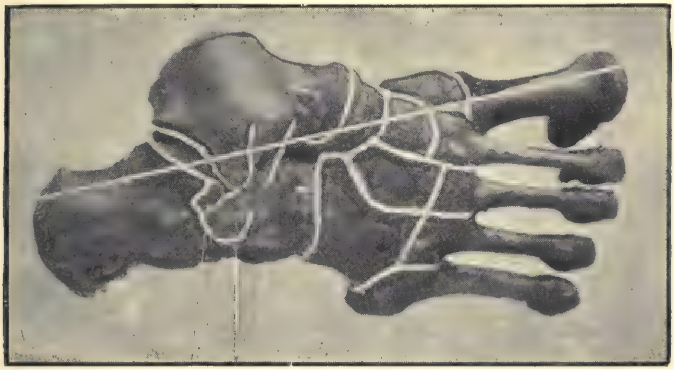



**Fig. 255.—The Skeleton of a Flat-foot. (From a specimen in the possession of Mr. Walsham, and now in St. Bartholomew's Hospital Museum.)**

**A straight line is drawn through the centre of the interphalangeal joint of the great toe and the centre of the upper surface of the os calcis, to show the deviation of the astragalus to its inner side. In a normal foot this line should pass through the centre of the trochlear surface of the astragalus. A, new articular facet on the os calcis for the external malleolus ; B, new articular facet on the os calcis for posterior fasciculus of external lateral ligament.**

cases, a facet external to the foramina, as seen in our specimen (Fig. 255, A), is formed for the apex of the external malleolus.

The *sustentaculum tali* is said in some cases to have been enlarged, and in others to have been much reduced, in size. In our specimen it is larger than usual. The facet on its superior surface has already been described (p. 418). The process is in contact postero-externally with the postero-external articular facet. Over

and above the depression inwards that it has undergone as part of the inwardly-rotated os calcis, it appears to have been still further depressed, so that when the bone is held in its normal position, its superior surface, instead of looking almost directly upwards, looks upwards and forwards.

The *anterior* or *cuboidal facet* is prolonged upwards and outwards on to a distinct crest formed by a heaping up of new bone, the cartilage on this portion of the facet being of the fibrous variety, an evidence, as pointed out by Rédard, of its new formation. In our specimen, and in some others of which descriptions have been published, this crest overhangs slightly the cuboid, thus tending to prevent the further displacement of the latter bone in an upward and outward direction. Below, the surface has been found deprived of cartilage, or the cartilage covering it thinned; whilst in some instances a new facet has been formed here for the long inferior calcaneo-cuboid ligament.

The *posterior surface* of the os calcis, in consequence of the rotation of the bone, is directed obliquely downwards and outwards, the external tuberosity being raised half an inch or more from the ground (Fig. 254).

The *external surface* (Fig. 255) has on it an articular facet for the fibula and the posterior fasciculus of the external lateral ligament. This articular surface consists of two portions. The posterior and smaller portion (Fig. 255, B) is contiguous to the external and posterior angle of the superior postero-external facet for the body of the astragalus, and articulates with the internal and posterior aspect of the posterior fasciculus of the external lateral ligament; the larger and anterior facet (Fig. 255, A) occupies a lower position, and is continuous with the lower angle of the superior postero-external facet for the astragalus. It articulates with the tip of the malleolus. The joint thus formed has acquired a well-marked capsule, and the plane of movement in it is antero-posterior.

The *internal surface* presents nothing especially remarkable.

**The Scaphoid**, as regards its relation to the head of the astragalus, is in an exaggerated position of abduction—*i.e.*, it is displaced outwards; whilst at the same time, in consequence of the depression of the head of the astragalus, it is also displaced upwards. In conjunction, however, with the great depression of

the bones on the inner side of the foot, it has further undergone a process of rotation on its antero-posterior axis. So that its tuberosity looks downwards towards the ground, and its dorsal surface directly inwards, the greater part of the inner and lower surface of the head of the astragalus being thus left exposed. In some instances the scaphoid has been found completely dislocated in an upward and outward direction on to the astragaloid neck. The bone has been found variously altered in shape, and at times unrecognisable. By Lorenz, it has been observed to have assumed a wedge shape, with the base directed downwards, and the apex upwards and outwards. This is its condition in our specimen. The facet for the head of the astragalus has been found partially denuded of cartilage at its upper and outer part; whilst in other specimens, as in ours, a new articular surface, corresponding to the heaping up of bone on the head of the astragalus, has been formed. In our specimen, the concave surface of the scaphoid for the head of the astragalus is moulded to the shape of the facet on the head of the astragalus. The dorsal surface of the bone, which is rotated so as to look directly inwards, presents a deep groove (Fig. 252) through its centre, due to the heaping up of new bone along the border of the articular surfaces for the astragalus and cuneiform bones respectively. The anterior surface for articulation with the three cuneiform bones is not materially altered, but looks, in correspondence with the abduction of the fore part of the tarsus, downwards and outwards. The facets for the cuneiform bones, however, have been found displaced slightly upwards and outwards.

By Chaput the scaphoid, in some instances, has been found ankylosed to the head of the astragalus and os calcis by bony spicula.

**The Cuboid,** in conjunction with the other bones of the tarsus, also undergoes a movement of rotation on its antero-posterior axis, so that its dorsal surface, which normally looks upwards and outwards, looks almost directly upwards. In shape it is very little altered, except perhaps in severe degrees of the deformity, when the normal inward inclination of the posterior facet for the os calcis may be exaggerated. In our specimen there is a slight heaping up of bone around the upper surface of this facet.

**The Cuneiform Bones** are also collectively rotated on their

antero-posterior axes, so that the dorsal surface of the external cuneiform, instead of looking upwards and outwards, looks almost directly upwards; and the dorsal surface of the internal cuneiform, instead of looking upwards and inwards, looks almost directly inwards.

**The Metatarsal Bones** have been found in some cases to be markedly adducted, the result, it is considered by Lorenz, of the contraction of the plantar muscles and the plantar fascia. We have not met with this condition ourselves, but we give a drawing of it from Rédard (Fig. 256).

**The Malleoli.**—The *external malleolus*, in severe cases, is in contact with the outer border of the os calcis, or even with that portion of the superior surface of the bone which lies immediately in front of the postero-external articular facet. Its extremity is

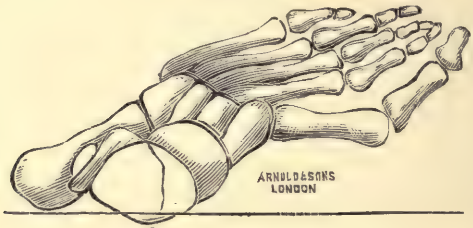



FIG. 256.—OUTLINE OF THE SKELETON OF A FLAT-FOOT, TO SHOW THE ADDUCTION OF THE METATARSAL BONES. (After Rédard.)

often blunted, and presents a new articular facet, surrounded with a distinct capsule for the contiguous portion of the os calcis. In a normal foot the external malleolus occupies a position posterior to the internal, and therefore a straight line joining them will lie in a plane directed forwards and outwards. Upon abduction (p. 25) of the foot, the external malleolus moves forward to a certain extent, so as to lie in the same transverse plane as the internal malleolus, the straight line joining them now lying on a plane directed straight forwards. In some persons abduction can be carried to so great an extent that the external malleolus occupies a position anterior to the internal malleolus, a straight line joining them now lying in a plane directed forwards and inwards. This is the condition in severe flat-foot; at least, it is

so in the specimen which we have now before us of an advanced grade of the affection.

The *internal malleolus* is as a rule but little altered.

**The Ligaments**.—The ligaments of the ankle and tarsus are, as a rule, in the earlier stages of flat-foot, all more or less relaxed. In the later and advanced stages, whilst some ligaments are stretched and elongated, others are shortened, and thus, together with the alteration in the shape of the bones and spastic contraction of the muscles, hold the foot in the distorted position.

1. *The Ligaments of the Ankle-joint.*—All the ligaments of the ankle-joint in the early stages of flat-foot are generally relaxed.

(A) The *anterior ligament*, beyond being somewhat stretched, is not materially altered.

(B) *The external lateral ligament.*—The *middle fasciculus* of the *external lateral* ligament (*fibulo-calcanean*) is elongated and wasted, and, in place of being directed downwards and backwards, has been found taking an almost horizontal direction backwards in consequence of the forward and downward displacement of the fibula and the rotation of the os calcis and depression of its anterior end. The *posterior fasciculus* of the external lateral ligament is stretched, and in some specimens is stated to have been very indistinct. The *anterior fasciculus* is shortened.

(C) *The internal lateral ligament.*—The superficial part of the internal lateral ligament (*tibio-calcaneo-scaphoid ligament*) is greatly stretched and thinned. The deeper portion of the internal lateral ligament, that attached to the astragalus, is not much altered.

2. *The Calcaneo-scaphoid Ligament*, especially the internal portion, is stretched, thus allowing the head of the astragalus to project downwards and inwards. The extent of surface of this ligament is as a rule markedly increased—at least we, with others, have found it so; but Meyer maintains that it is not increased in length, but that the increase is only apparent, the outer border of the foot being diminished, the inner border not altered.

3. *The Calcaneo-astragaloid Ligaments.*—(A) The *internal calcaneo-astragaloid* (interosseous) ligament is stretched, wasted, and is said at times to have completely disappeared.

(B) The *external calcaneo-astragaloid* is elongated.

(c) The *posterior calcaneo-astragaloid*, beyond being stretched, is not otherwise altered.

**The Muscles.**—The muscles in the acquired form are all healthy in structure, but generally somewhat small and wasted. The muscles of the calf are, as a rule, especially small. The peronei are, in advanced cases, tense, either from spasm or from adaptive shortening. The tendo Achillis is in some instances shortened, as are also the dorsal flexor muscles.

### General View of the Skeleton of Flat-foot.

Having discussed in detail the changes in the bones, ligaments, and muscles, we may now take a general view of the skeleton of flat-foot as a whole. On looking at the *inner border* (Fig. 252), besides the marked depression of the tarsal bones, it is seen that the depth of this border is much increased. This is due in part to the rotation of the bones downwards and inwards on an antero-posterior axis, causing more of the dorsal surface of the bones to look inwards, and in part to the formation of new bone both at the lower and inner and upper and outer aspects of the astragalus and scaphoid respectively. The downward and inward rotation of the bones upon an antero-posterior axis is, perhaps, most apparent in the first metatarsal bone, since, in consequence of the rotation, its dorsal surface looks almost directly inwards (Fig. 252) instead of upwards and slightly inwards, as in the normal foot.

The smooth facet for the tibialis anticus on the lower and anterior angle of the internal cuneiform bone is much larger than normal, and extends well on to the plantar surface.

The tendon of the *tibialis posticus*, in place of occupying a position somewhat internal to the head of the astragalus before it reaches the lower aspect of that bone, on its way to its insertion into the tubercle of the scaphoid, passes from the first quite beneath the head of the astragalus (Fig. 252). This alteration in the relative position of the tendon depends partly on the downward and inward displacement of the head of the astragalus, and partly on the rotation of the scaphoid, whereby the tubercle becomes the lowest point of the bone, and looks directly downwards.

The *sustentaculum tali* is with difficulty seen from the inner

side of the foot, being rotated downwards and inwards with the os calcis, so as to be almost completely hidden from view. The large *heaping-up of bone* at the upper and outer side of the astragalo-scaphoid joint has already been referred to at some length. Here it need only be said that it takes a part, and a considerable part, in the increase of depth of the inner border of the foot. If the bones were in their normal relation with each other, the whole of this new bone would be on the dorsal surface of the foot

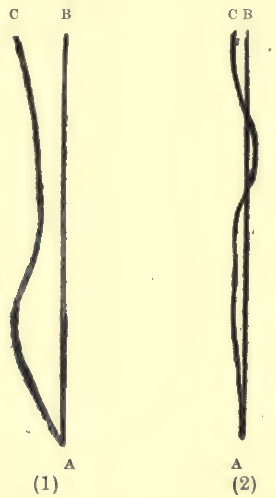



FIG. 257.

In (1) and (2) A B is the straight line obtained by producing the innermost point of the posterior portion of the os calcis directly forwards. In (1) A C is the line obtained by joining the innermost points of the bones on the inner surface of a flat-foot. In (2) A C is the outline obtained by joining the innermost points of the bones on the inner surface of a normal foot with a large low arch to instep.

The inner edge of a normal foot may be said to lie in a straight line drawn directly forwards from the inner border of the posterior end of the os calcis. The inner border of the first metatarsal bone should correspond to this line, and the innermost portion of the internal cuneiform, scaphoid, and astragalus should also roughly correspond to it. In feet with a well-marked instep the innermost portions of these bones will lie to the outer side of this line; in

those with a low arch, to the inner side. In well-marked flat-foot, as in the severe grade seen in Fig. 252, this straight line, in consequence of the rotation of the os calcis, will reach the space between the second and third toes, so that no inner edge comparable to that of the normal foot can be described, whilst the line joining the innermost projections of the bones on the inner side of the foot will form an irregular curve, with a marked convexity inwards (Fig. 257).

Turning to the *outer border of the skeleton* of flat-foot (Fig. 253), it will be seen that the anterior portion of the os calcis and cuboid are nearer to the ground than normal, the arch formed by the outer border of the foot being somewhat depressed. Along the dorsal edge of the anterior surface of the os calcis is heaped up a mass of new bone, forming a distinct crest or ridge, whilst along the dorsal edge of the posterior surface of the cuboid is a similar but less extensive heaping-up of new bone (Fig. 253).

The outer edge of the foot, besides being somewhat depressed, is also everted, in consequence of the rotation of the foot upon its antero-posterior axis; the external inferior tubercle of the os calcis, as the result of this rotation, is raised three-quarters of an inch or so off the ground. The external malleolus, it will be seen, is in contact and articulates with the outer surface of the os calcis (Fig. 254).

Looked at *from above*, all the foot anterior to the transverse tarsal joint is seen to be quite flat as far as the spaces between the metatarsal bones, except the portion of the scaphoid adjacent to the astragalus. The foot immediately posterior to the transverse tarsal joint is unusually prominent, owing to the ridge of new bone on the astragalus and os calcis.

Viewed from this aspect, moreover, the marked abduction of the anterior portion of the foot is very evident. A line drawn through the middle of the new dorsal surface of the first metatarsal bone, if prolonged backwards, will just miss the astragalus and the tibia, and hit off the inferior tibio-fibular articulation (Fig. 255).

If a straight line be drawn from the mid-point of the tibial articular surface in the plane in which the flange of the tibia lies, it will be found to fall at least an inch and a half to the inner side of the head of the first metatarsal bone.

Though the head of the astragalus is depressed and rotated

inwards, yet the upper and outer portion, especially that part newly formed, seems to follow the line of the abducted portion of the tarsus, its direction being almost at a right angle to the original direction of the head and neck of the bone.

Looked at *posteriorly* (Fig. 254), the rotation of the os calcis downwards and inwards upon its antero-posterior axis is strikingly apparent. The great bulk of the bone is seen to lie behind the fibula, only a very small portion of the bone, namely, that adjacent to the posterior external articular surface, lying behind the tibia, and even that behind the most external portion of the tibia. The lifting up of the external inferior tubercle, and the manner in which the os calcis rests upon the internal inferior tubercle, are also well shown when the foot is viewed from this aspect, as is, too, the increase in size of the sustentaculum tali, and the general oblique position of the os calcis as a whole.

## SIGNS AND SYMPTOMS OF STATIC FLAT-FOOT.

The signs and symptoms of flat-foot may now be discussed at length, under the following heads:

1. **Pain.**—Except in very slowly advancing cases, as those occurring in children with weak ankles, or who have never developed an arch at all, pain is an almost invariable accompaniment of flat-foot. It differs, however, in its intensity and situation, and does not necessarily depend upon the amount of the deformity.

*The Situation of the Pain.*—Pain is most often situated (1) about the inner half of the mediotarsal joint; (2) about the outer half of the mediotarsal joint; (3) beneath the external malleolus; (4) in the metatarso-phalangeal joint of the great toe. Besides the pain in these more or less definite situations, patients not infrequently complain of vague pains across the anterior part of the dorsum of the foot, in the sole of the foot, in the calf, and even up the thigh.

*Causation of the Pain.*—The pain depends on various causes. In some situations it would appear to be due to overworking of muscles and tendons; in some to stretching of ligaments; in others, to impaction of bones against each other, or against the surface walked upon.

To take these seriatim: (1) *Overwork of Muscles and Tendons*, in the task of keeping the body erect when its proper bearings on its supports are disturbed, is probably responsible for the vague pains felt in the soles and the calves, and sometimes in the thighs. These pains, the exact situation of which cannot be accurately determined, are undoubtedly due, says Sir James Paget,* 'to impairment of composition which ensues in the muscles during exercise, becoming at last greater than can be repaired in their ordinary repose, or when the general health is enfeebled.'

(2) *Stretching of Ligaments* probably occasions the pain (*a*) at the inner ankle, at which situation the deltoid ligament and the internal calcaneo-astragaloid or interosseous ligament are subjected to continual strain; (*b*) at the inner end of the mediotarsal joint, especially about the inner and under aspect of the head of the astragalus, the calcaneo-scaphoid ligament being here stretched by the descent of the head of the astragalus. The head of this bone in its descent, moreover, will pull upon the ligaments connecting the body of the bone with other of the bones of the ankle and foot, and thus give rise to pain in the situation of the ligaments thus stretched, and may account for some of the indefinitely situated pains in various parts of the foot.

(3) *Impaction of Bones against each other or against the Surface walked on.*—To the impaction of bones against each other may be attributed the pain in the dorsum of the foot—that is, about the upper part of the mediotarsal joint. Owing to the peculiar displacement of the bones, the upper portions of the scaphoid and cuboid are impacted against the astragalus and os calcis respectively, and this pressure, which is intermittent, is no doubt in part accountable for the periostitis and osteitis, and subsequent formation of new bone along the upper border of the joint. This is perhaps one of the commonest causes of pain in flat-foot, the pain being generally referred by the patient to the instep, and more often to the inner than to the outer side. To impaction of bones against each other is likewise due the pain below the external ankle and on the outer side of the foot. In the former situation it is caused by the os calcis in its rotation coming into contact with the external malleolus, and as the result of

* Paget, *Medical Times and Gazette*, vol. i., 1858, p. 260.

the friction thus occasioned a new joint, as pointed out in the section on pathology, is sometimes formed. In the latter situation it is due to the crushing together of the bones at the outer side of the mediotarsal joint, due to the elongation of the inner border of the foot. Impaction of bone against the surface walked on is responsible, in part, for the pain at the inner end of the mediotarsal joint, *i.e.*, over the head of the astragalus and tubercle of the scaphoid, upon which portions of bone, in advanced cases of flat-foot, the patient treads. The friction thus resulting is probably a factor in the production of the chronic periostitis, which is sometimes met with in these situations, and which leads to the new formation of bone about the joint and causes the extreme tenderness and acute pain on pressure often met with here. The effusion in the surrounding soft tissues which may accompany these inflammatory changes may also be in part accountable for some of the pain.

The remaining situation of pain, *i.e.*, in the metatarso-phalangeal joint of the great toe, may be discussed separately. The cause of the pain in this situation has been the subject of much dispute. The toe is held rigidly, either in the normal position, or at times more or less in the plantar-flexed position, and more rarely in the dorsal-flexed position. With the toe at rest, no pain is, as a rule, felt; but the most exquisite agony is produced by the surgeon moving the toe, plantar flexion, in our experience, causing the most suffering in the majority of cases. Our explanation of the cause of the pain in this joint is that it is due to the stretching and spastic contraction of the long dorsal flexor of the hallux. This stretching and spasticity is brought about, we believe, as follows: As the arch of the foot yields, the scaphoid with the head of the astragalus is depressed, and to some extent the internal cuneiform and the first metatarsal bone, especially at its base. This sinking of the bones on the inner side of the foot pushes the phalanges of the great toe directly forwards, and would push them more forwards were they not held back to some extent by the long plantar flexor, which is attached to the base of the distal phalanx, and by the abductor, adductor, and short flexor muscles of the hallux, which are attached to the base of the first phalanx. But the proximal end of the first metatarsal being depressed, and the base of the first phalanx being held

down and plantar-flexed by the united action of the short muscles, the distal end of the metatarsal bone is raised, and the lower part of its head is pressed against the base of the first phalanx. So that whilst the articular surfaces are firmly impacted at their lower half, their dorsal portions are somewhat separated, leading to the stretching, and consequent spastic contraction, of the dorsal flexor tendon. This condition of things is probably helped by the dorsal ligaments being practically absent, their place being taken by the long dorsal flexor tendon, while the plantar ligament, the so-called glenoid plate, is very thick and strong.

Further, the impaction of the bones entering into the metatarso-phalangeal articulation of the great toe is no doubt, we think, materially aided by the patient wearing too short a boot; the toe, coming under these circumstances into contact with the end of the boot, is prevented from being pushed forwards by the sinking of the metatarsal bone, and hence is forced as well as pulled by the muscles, as above explained, into the impacted position. We have in a very large number of cases found that, when pain in the metatarso-phalangeal articulation is complained of, there has been a combination of incipient flat-foot and the wearing of too short a boot. We have been told by the patient that his boot was not too short, but inspection of the boot has convinced us to the contrary; and although the foot in some cases might not to a casual observer show any flatness, some slight depression of the arch and lengthening of the inner side of the foot, together with a history of long-standing or weight-bearing, was nearly always present.

Some authors have put forward the theory of arthritis as an explanation of the pain in flat-foot, but we do not think we need introduce any new element of the kind. We hold, as explained above, that it is the natural outcome of the events taking place in the development of the deformity. The proof of the view that the pain of flat-foot depends in chief part on the disturbance of the proper bearings of the body on its supports lies, we think, in the fact that directly the said disturbance is rectified, or when the weight of the body has no longer to be maintained, as when the patient is taken completely off his feet, the pain is immediately relieved, and soon ceases altogether.

In rheumatic flat-foot, in addition to the pain depending on the deformity, there is generally some pain due to the disease itself, especially in the tendons, ligaments, and other fibrous structures. Pain at the attachment of the tendo Achillis and plantar fascia into the os calcis is particularly characteristic of the rheumatic affection.

2. **Swelling.**—Subcutaneous bursæ, already referred to in the description of static flat-foot, may occur over the internal malleolus, head of the astragalus, tubercle of the scaphoid, and in the region of the metatarso-phalangeal joint of the great toe. In the latter situation they are more common on the inner than on the outer side. Besides these various adventitious bursæ, a local puffiness may occur, especially over the dorsal surface of the head of the astragalus, or there may be a general puffiness of the whole foot. In some cases, especially the rheumatic, marked swelling may be present about the ankle, particularly on the inner side. This swelling usually depends upon effusion into the sheaths of the tendons.

3. **Alteration in Gait.**—The gait which may be said to be typical of the deformity is perhaps well described as laborious and painful, with a total loss of elasticity, the feet appearing, so to speak, as hindrances rather than aids to progression. This peculiarity in gait is brought about, not merely by the pain which is experienced in walking, but also by the rigidity of the foot, the movements of the tarsal bones upon one another being greatly restricted, and in some advanced cases abolished. Indeed, the only movement in advanced cases may take place at the ankle-joint, and here again may be very considerably limited, on account of the greatly altered position of the astragalus and the contraction of the tendo Achillis and dorsal flexor muscles. The most noticeable diminution in movement occurs in the astragalo-scaphoid articulation, in consequence of the greater alteration that takes place in the bones forming it. Raising the body on tip-toe, inverting the foot so as to stand on its outer edge, and circumducting the foot, are rendered impossible in severe cases. If the patient endeavours to raise himself on tip-toe, a kind of rocking movement of the foot upon the leg is the only result, the posterior part of the foot being merely

slightly lifted off the ground. On endeavouring to circumduct the foot, it is only rocked to and fro.

4. **Relative Position of the Internal Malleolus, Head of the Astragalus, and Tubercle of the Scaphoid.**—In the normal foot a line joining these points should form a gentle curve, with the convexity upward; in a flat-foot, a similarly-drawn line, even in a case of medium severity, is curved with its convexity downwards, in consequence of the downward displacement of the astragalus. In Fig. 243 the situation of these points has been marked by black dots.


FIG. 258.—FLAT-FOOT WITH EXTREME VALGUS CONDITION OF ALL THE TOES. (From a photograph of a cast in St. Bartholomew's Hospital Museum.)

5. **Flattening of the Sole.**—The amount of flattening of the sole can be well demonstrated by taking an impression of the foot by wetting the sole in warm water, and placing it on a sheet of blotting-paper. When such an impression is taken of the normal foot, only a part of the heel, the outer part of the sole, and the balls of the toes, are represented (Fig. 8). In flat-foot more and more of the sole is marked on the blotting-paper,

according to the degree of flattening. A severe case will present the appearance shown in Fig. 250, the whole inner border of the sole being in contact with the ground.

6. **Sweating of the Foot.**—Sweating of the foot is said, by most authors, to be a characteristic symptom.

## VARIETIES OF ACQUIRED FLAT-FOOT.

The following varieties of acquired flat-foot may be described: (1) The traumatic; (2) the paralytic; (3) the spastic or spasmodic; (4) the rickety; (5) the rheumatic; (6) the hysterical; (7) the flat-foot of ankle-joint disease.

The 'pied creux valgus' of Duchenne is described under Talipes cavus.

1. **Traumatic Flat-foot** does not differ in its essential characteristics from the ordinary form of static flat-foot, except in the fact that it is sudden or rapid in its formation, and intractable in its nature. It is produced either by direct violence, such as a blow or a weight falling across the instep, or by indirect violence, such as a fall from a height on to the sole of the foot. In the latter instance we have generally found that the patient had previously a low instep; that is, a tendency to flat-foot. Patients often attribute their flat-foot to a sprain or injury, when, probably, such had little or nothing to do with the causation of the condition. On the other hand, we have seen many cases where the flat-foot appeared undoubtedly to owe its origin to a traumatism, although the predisposing causes of flat-foot were present. In several cases there could be no question between cause and effect. It was quite evident that the flat-foot, that is, the displacement of the bones, was produced at the time of the injury. In one of the most marked cases that came under our notice, the patient, a sailor, dropped from the mast on to the soles of his feet, and the flattening of the feet appeared as soon as the swelling produced by the injury cleared up. When we saw him both feet were quite flat. In such cases it would appear that the ligaments supporting the arch are ruptured, and the bones are forced at once into the valgus position, or rapidly take this position as the patient begins again to walk.

The intractable nature of traumatic flat-foot is explained by the

rupture and stretching of the ligaments maintaining the arch of the foot, and the disadvantage at which they are placed for repair in consequence of the weight of the body in standing and walking still further separating their attachments, as the bones are thus more and more depressed, everted, and abducted.

There is another form of so-called traumatic flat-foot, namely, that following fractures and dislocations about the ankle. It is most frequent in connection with a badly-set Pott's fracture. Here the deformity is due in part to an incomplete reduction of the outward and backward displacement of the foot at the ankle-joint, and in part to a secondary giving way of the arch—as in

FIG. 259.—PHOTOGRAPH OF A CAST OF THE RIGHT LEG AND FOOT FROM A CASE OF INTRA-UTERINE FRACTURE OF THE RIGHT TIBIA IN ITS LOWER THIRD WITHOUT UNION. (No. 104, St. Bartholomew's Hospital Museum.)

The lower extremity of the upper fragment projected forwards and inwards.

ordinary static flat-foot—in consequence of the weight of the body, in standing and walking, being thrown too much on the inner side of the foot, as the result of the non-reduction at the ankle. The appearance is quite characteristic. In addition to the ordinary signs of flat-foot, the internal malleolus projects prominently, the whole foot is everted, and the fibula presents the receding angle a little above the external malleolus characteristic of a Pott's fracture. The thickening and callous formation about

the internal malleolus and at the seat of fracture in the fibula, together with limitation of movement at the ankle-joint and the history of the injury, should make the diagnosis clear. In this form pain and difficulty in walking is an especially marked feature,

FIG. 260.—PARALYTIC VALGUS. (From a photograph of a patient attending the Orthopædic Department of St. Bartholomew's Hospital.)

and it may be even impossible to walk at all without the aid of a stick or crutch.

Under the head of traumatic valgus may be also placed those rare cases of intra-uterine fractures of the tibia occasionally met

with. An illustration is appended of valgus following an intra-uterine fracture of the tibia in its lower third (Fig. 259).

2. **Paralytic flat-foot** is generally the result of infantile paralysis, and consequently is as a rule met with in childhood. It is the result of paralysis affecting the anterior tibial muscle, or both

FIG. 261.—A CASE OF VALGUS FOLLOWING UPON INFANTILE PARALYSIS IN A BOY EIGHT YEARS OLD. (From a photograph taken in the Orthopædic Department of St. Bartholomew's Hospital.)

The left leg and foot are wasted, the muscles on the inner side being most affected.

the anterior and posterior tibial muscles, or sometimes the dorsal flexors as well. In the last case there is generally a combination of valgus with equinus—a condition treated of under equino-valgus (p. 331).

At other times the calf muscles, as well as the tibials, are also

paralyzed; the condition known as calcaneo-valgus then results (p. 385). In the case of pure paralytic valgus, depending on paralysis of the tibialis anticus, or tibialis anticus and posticus, the inner border of the foot, having lost the support of these muscles, sinks towards the ground, and the sole becomes flat and the outer border everted and raised, whilst the peronei undergo adaptive shortening and become contracted and tense. At times, however, the peronei are not found contracted. The foot can then be readily restored to the normal position by manipulation, but it at once falls back again into the valgus state when the hand is removed. Paralytic valgus is frequently associated with paralytic varus or equino-varus of the opposite foot.

Under the term *pied plat valgus douloureux*, Duchenne describes a form of painful flat-foot due, he believes, to paralysis of the peroneus longus.

Duchenne maintains that the plantar arch is sustained solely by the peroneus longus, the action of this muscle being to hold down the head of the first metatarsal bone and the other bones, namely, the first cuneiform and scaphoid, which form the anterior half of the plantar arch. When the peroneus longus is paralyzed, he says, the head of the first metatarsal bone gradually rises, drawing with it the first cuneiform and the scaphoid in such a way that the plantar arch gradually disappears, and so the foot becomes flat. At first, he says, the plantar surface of the foot looks inwards, and only touches the ground by its external border, since the patient has lost the power of contracting his peroneus longus. As the result of the anterior part of the foot resting upon its external border, the weight of the body causes abduction to take place at the calcaneo-astragaloid joint, the tibialis posticus being unable to bear the strain of continually resisting this movement. Later, the valgus position is rendered permanent by the consecutive contraction of the peroneus brevis and the common extensor of the toes. The pain is attributed to the continual strain and stretching of the calcaneo-astragaloid joint. Rédard is of opinion that this theory holds good in a certain number of cases, such cases occurring chiefly in patients between the ages of fifteen and twenty-five, both feet being generally affected. The foot is flat; it turns on its inner side when voluntarily extended, and the patient cannot apply the head of

his first metatarsal bone to the ground, nor balance himself upon the affected foot. If, according to Duchenne, pressure is made on the plantar surface of the great toe, little or no resistance can be exerted on the part of the patient. Trophic changes, such as corns, callosities, abrasions and ulcers, are met with about the centre of the external border and plantar surface of the foot. Electrical examination shows the peroneus longus to be paralyzed.

We have stated our objections to the view of flat-foot being due, save, perhaps, in exceptional cases, to paralysis of the peroneus

Fig. 262.—Rickety Flat-foot in a Child aged Seven Years. (From a photograph of a patient in the Orthopædic Department of St. Bartholomew's Hospital, taken by Mr. Clindening.)

The great toe is seen to be much everted and rotated. The foot is quite 'flat,' and there is some valgus of the ankle in addition.

longus under the head of etiology. We may repeat here that we have hitherto never met with a case in which this muscle was found so affected.

3. **Spastic or Spasmodic Flat-foot** is an uncommon variety, but is occasionally met with in spastic paraplegia. In this affection, equino-varus, as pointed out by Mr. Adams, is the more common condition, for the reason, as he says, that, all the muscles of the leg being affected, those of the greatest bulk—the strongest

muscles—gain the ascendancy. The foot is held in the position of valgus; the sole is flat, in extreme cases may even be convex. As in other deformities of the foot depending upon spastic paraplegia, the muscles, when the foot is taken hold of and an attempt made to restore it to the natural form, gradually yield and the deformity disappears, but at once returns when the pressure is relaxed. In cases of this affection that have reached adult life, the muscles are said to become tense and rigid and the foot inflexibly fixed in the valgus position by the peronei and dorsal flexors. We have not personally met with this condition.

FIG. 263.—PHOTOGRAPH OF THE FEET AND LEGS FROM A SPECIMEN OF SEVERE RICKETS. (From St. Bartholomew's Hospital Museum.)

The tibiæ are bowed inwards, the feet are in the position of valgus. The bones of the foot retain almost completely their natural shape, but are somewhat smaller than normal. The valgus is evidently due to relaxation of the ligaments and muscles, and not to any softening and alteration in the shape of the bones.

4. **Rickety Flat-foot.**—Flat-foot is exceedingly common in rickety children. Nearly all the cases of flat-foot we have met with in children under ten were due to rickets. It is most often seen about the fifth or sixth year, and is frequently preceded by a valgus condition of the ankles (*weak ankles*). It appears to us that flat-foot in rickets is due in part to the general want of tone in

the muscles and ligaments, and in part to the altered direction in which the weight of the body is transmitted from the leg bones to the foot. By some authors, as Rédard,* it is attributed chiefly to a softening of the bones. Although softening of the bones may have something to do with it, we do not admit that it is the chief

FIG. 264.—PHOTOGRAPH OF THE SKELETON OF A FLAT-FOOT FROM THE SPECIMEN OF RICKETS WITH MARKED INWARD BOWING OF TIBIÆ SHOWN IN FIG. 263.

cause; for, apart from the fact that the small bones are but little affected in rickets, a softening of their texture would produce a bending or an alteration in shape rather than the twisting and

* Rédard, 'Traité de Chirurgie Orthopédique,' p. 805.

rotation of the bones on each other, as occurs in flat-foot, and for which a certain amount of strength in their texture is necessary.

Further, that the alteration in flat-foot is not due to a bending of softened bones is shown by the absence of any evidence in the shape of the bones themselves in early cases. The ease and rapidity with which slight cases can be cured also point to muscular and ligamentous rather than osseous changes.

In the want of tone in the muscles and ligaments found in

FIG. 265.—FLAT-FOOT WITH GENU VALGUM. (From a photograph of a patient the subject of rickets attending the Orthopædic Department of St. Bartholomew's Hospital, taken by Mr. Clindening.)

rickets we have a predisposing cause; and if the child is allowed to be on his feet, we hold that the flat-foot follows as in the ordinary static form. But in rickets there is, further, an exciting cause, namely, the alteration in the direction in which the weight is transmitted to the foot, consequent upon the alteration in the shape of the leg bones. Thus, rickety flat-foot is frequently associated with bow-legs, curving inwards of the tibiæ, as in

Fig. 265, and knock-knee. In bow-legs, the lower or trochlear surface of the tibia, instead of looking directly downwards, as in the normal foot, looks downwards and more or less inwards, according to the amount of bowing of the shaft of the tibia and fibula. The astragalus being held firmly between the malleoli, its lower articular surface also looks in the same direction, namely, downwards and inwards instead of downwards. The remaining tarsal bones, in order that the child may place his foot with the sole to the ground, have consequently to undergo a rotation in the direction of eversion and abduction, while the eversion and abduction, as the curvature of the tibia increases, pass into the condition of veritable flat-foot. The want of tone in the muscles and the ligaments allows this eversion and abduction more readily to occur.

When the tibia and fibula, as in Fig. 263, take an inward bend instead of the more common outward bow, as also in knock-knee, the weight is transmitted more to the inner side of the tarsus than natural, and the foot, as the ligaments gradually yield, becomes everted and adducted, and finally flat. By some authors the flat-foot is regarded as the cause of knock-knee. As far as our observations go, the flat-foot and knock-knee in rickets generally run coincidently. A good example of flat-foot with knock-knee is given in Fig. 265.

With the exception of the specimen in our museum, we have had no opportunity of dissecting a rickety flat-foot. In this specimen (Fig. 263) the long bones show extreme rickety changes, but the bones of the foot have retained almost completely their normal shape. Our clinical experience would also lead us to think that it is the exception rather than the rule for any marked alteration to occur in rickets in the tarsal bones, and we have not found these cases so very intractable as regards treatment. Mr. Adams, however, would appear to regard an alteration in the shape of the bones as not uncommon. He says, in speaking of this variety of flat-foot, that the deformity of the bones, like the other deformities of rickets, remains as a persistent condition after the spontaneous cure of the disease and solidification of the bones. This, he says, is the only variety of non-congenital valgus in which the bones become materially altered in form, and the readiness with which the softened bones mould themselves to

the distorted position of the foot materially adds to the intractable nature of the deformity.

5. **Rheumatic Flat-foot**, or flat-foot which follows on an attack of rheumatic fever or gonorrhœal rheumatism, corresponds in general details with ordinary static flat-foot, but is marked by more or less effusion in the neighbourhood of the ankle and mediotarsal joints and along the tendons of the foot muscles. Effusion, however, is not uncommonly met with in ordinary flat-foot, but then only, as a rule, in the sheath of the tendons about the inner ankle.

FIG. 266.—EARLY RHEUMATIC FLAT-FOOT, SHOWING SWOLLEN CONDITION OF THE INNER ANKLE. (From a photograph of a patient attending the Orthopædic Department of St. Bartholomew's Hospital, taken by Mr. Griffiths.)

Sometimes flat-foot develops in rheumatic subjects without any noticeable effusion, but still runs the same refractory course as when that sign is well marked. Fig. 266 represents an excellent example of the general puffiness about the inner ankle and inner part of the foot, so characteristic of the rheumatic form, and Fig. 267 represents an advanced case of long duration, which defied for many months all attempts at replacement of the bones by the method of wrenching. Relapses are exceedingly common

in the rheumatic form, in many instances the ligaments appearing to have undergone profound structural alterations.

6. **Hysterical Flat-foot.**—A valgus condition of the foot is sometimes met with in hysteria, but much less frequently than varus or equino-varus. The cases we have seen have been in young girls with other signs of hysteria. The foot was held in the position of valgus, and attempts at reduction were resisted, but could be overcome when the muscles were tired out, the foot then assuming its normal shape.

Fig. 267.—Advanced Rheumatic Flat-foot, with Hammer Toe and Hallux Valgus. (From a photograph taken in the Orthopædic Department of St. Bartholomew's Hospital by Mr. Clindening.)

7. **Valgus due to Ankle-joint Disease.**—Tubercular disease of the ankle or of the astragalo-scaphoid joint occasionally gives rise to a valgus appearance of the foot. In the inflammatory affection the presence of heat, more or less swelling, limitation of the swelling to the affected synovial membrane, the character of the pain, the elicitation of pain on movement of the foot or on striking the heel or sole, the wasting of the limb, and the history

of tubercle or signs of it in other situations, will generally suffice for the diagnosis. In the earlier stages, however, it is sometimes exceedingly difficult to distinguish the tubercular affection from the ordinary static form, and we have seen mistakes frequently made.

## DEGREES OF ACQUIRED FLAT-FOOT.

For the sake of convenience, acquired flat-foot may be divided into several degrees. Thus:

FIG. 268.—COMMENCING FLAT-FOOT. (From a photograph of a patient in the Orthopædic Department of St. Bartholomew's Hospital, taken by Mr. Griffiths.)

The arch is slightly more depressed in the right than in the left foot. First degree left side, second degree right side.

**First Degree, or Incipient Flat-foot.**—In this degree the displacement of the bones is so slight that the arch is restored when the patient is seated, rises upon tip-toe, or inverts the foot when standing. The ligaments are only stretched a little beyond the normal, and when the superincumbent weight is removed the bones resume their normal condition. In slightly more advanced cases (Fig. 268) the muscles still retain the power of momentarily

restoring the arch when acting suddenly and to the best advantage, as by making the patient raise himself quickly to tip-toe with the feet slightly adducted (see Chapter I.). In this degree there is no rigidity.

**Second Degree, or Pronounced Flat-foot.**—In this degree the arch is not restored when the patient is seated or raises himself on tip-toe, though the surgeon, on manipulation, is able to reduce the deformity with only a moderate amount of force. The patient is unable to evert the foot so as to stand on its outer edge. The deformity is due either to further displacement of the bones or to superadded spasm of muscles. Spasm of the muscles, it should be borne in mind, has little or no relation to the amount of deformity, as it is met with where there is but slight displacement of the bones, and on the other hand may be absent when the displacement is considerable. In both cases the patient is unable by his own efforts to restore the arch, since the weakened calf muscles and plantar flexors of the foot either act at a disadvantage by reason of the displacement of the bones, or are overpowered by the spasm of the peronei muscles. In still more advanced cases the patient cannot, for like reasons, even raise himself on tip-toe. To reduce the deformity by manipulation, the surgeon should grasp the anterior part of the foot with one hand (the left hand for the right foot, and *vice versâ*), the fingers being applied to the dorsum, and the thumb to the plantar surface. The fingers of the other hand should grasp the heel, the thenar eminence being applied to the displaced head of the astragalus. With the anterior hand he should now rotate the foot inward and adduct it, while he presses on the astragalus in an upward and outward direction with the thenar eminence of the other hand, and at the same time pulls the posterior portion of the os calcis forwards and inwards by the fingers. The reduction should be performed slowly and with gentleness, as it often causes acute pain, especially where there is any spasm of the peronei muscles.

**Third Degree, or Advanced or Rigid Flat-foot.**—In this degree the patient is unable to reduce the deformity by his own muscular efforts ; nor can the surgeon reduce it by manipulation, without using such force as would cause agonizing pain. The maintenance of the deformity is due either to spasm of the peronei, which are seen to stand out tensely at the outer ankle, or to ligamentous

adhesions. If due to the former, the foot becomes quite flaccid and of normal appearance when the patient is fully anæsthetized. If due to the latter, it cannot be restored to the normal shape until the adhesions have been broken down by the methods of manipulation mentioned under the second degree.

Amongst the severe cases that have come under our observation during the last twelve years, there have only been one or two in which it was not possible to reduce the deformity by manipulation under an anæsthetic, and thus relieve the patient. Moreover, neither Mr. Willett nor Mr. Marsh, who had charge of the

FIG. 269.—ADVANCED FLAT-FOOT (THIRD DEGREE). (From a photograph of a patient in the Orthopædic Department of St. Bartholomew's Hospital, taken by Mr. Griffiths.)

**The plantar arch has completely given way in both feet, and in each foot the great toe is seen to be slightly plantar flexed.**

Orthopædic Department previous to Mr. Walsham (Mr. Willett for some seventeen years) met with a case that could not be thus reduced.

**Fourth Degree, or Extreme or Osseous Flat-foot.**—In this degree the sole is convex, and osseous changes, such as are seen in Fig. 254, have occurred about the mediotarsal joint. The deformity cannot be reduced, even with the patient under an anæsthetic.

We have, as stated under the third degree, met with only one or two examples of these severe cases. Since, however, they appear to have been met with more frequently in the practice of Professor Stokes, Professor Ogston, and others, we must suppose that their occurrence is more common than our statistics would lead us to believe. Whilst admitting this, however, we cannot help feeling at the same time that possibly many of the cases for the relief of which operations on the tarsus were performed, might have been reduced by manipulation under an anæsthetic.

## CHAPTER XII.

### TREATMENT OF ACQUIRED FLAT-FOOT.

THOUGH flat-foot is essentially a local affection, and calls for local treatment, it must not be forgotten that in many cases, as in the rheumatic, the rachitic, the debilitated, etc., constitutional remedies, with all attention to the general health, are of the greatest service. The treatment, therefore, should be both local and constitutional.

**Local Treatment.**—The local treatment varies according to the kind and degree of the deformity. We shall first describe the methods we have found most successful for ordinary cases of static flat-foot; then point out which of these methods is most applicable to the various degrees of the deformity; and lastly discuss the treatment or modifications of treatment that may be necessary in special forms.

*Treatment of Ordinary Static Foot.*—Put broadly, the local treatment in all ordinary cases may be said to consist in *rest*, *exercises*, and proper *foot-clothing*, combined, according to the severity of the case, with *manipulative* and *mechanical* treatment, whilst in very severe cases *operative* treatment may have to be resorted to.

*Rest.*—Rest in bed or on the couch, with the weight of the body entirely removed from the feet, will alone do much to relieve the pain and discomfort in ordinary slight cases, by enabling the ligamentous structures in the sole to regain in some degree their tone, and by taking off the pressure from the displaced parts. Rest—that is, absolute rest—however, will be seldom submitted to. In private patients the discomfort produced by the deformity is not often such that they will submit to it, and hospital patients can rarely spare the time, even

were it possible to admit them into the wards. Rest, however, although not absolute, may still be beneficially employed, both in private and hospital work. The patient should be enjoined to sit, whenever possible, with the legs raised on a chair, so as completely for the time to remove all weight on the stretched ligaments. When sitting for any length of time is impracticable, and the occupation demands long standing, rest to the stretched ligaments may to some extent be obtained by the patient inverting his feet and standing with the inner edge of the sole of the boot supported by the inner edge of the sole of the opposite boot. In this way the arch is thrown up on the inner side, and the constant pressure on the ligaments for a time removed. The comfort of thus resting during long hours of standing is very great. Rest to the ligaments may also be obtained by rising to tip-toe occasionally in the way to be described under *Exercises*. Another way of putting the foot at rest is to place the foot and ankle in plaster of Paris, in a position of adduction and inversion with some extension. If a broad heel and flat sole is made to the plaster case in the way described later, the patient can get about, with a large slipper on, very comfortably. For hospital patients with flat-foot of moderate severity, it is an exceedingly useful method of treating them till some mechanical apparatus can be obtained. The objection to thus fixing the foot is that it prevents the exercises—the most important part of the treatment—being employed, an objection, however, that can hardly hold where the foot is at all rigid, and exercises consequently cannot be done. After, say, a month in plaster, the rigidity, if slight at first, may almost or completely have disappeared, the pain have ceased, and the foot have become capable of restoration on manipulation, or by the patient's own efforts on standing on tip-toe or on the outer edge of the foot. The foot is now in the best condition for the application of a surgical boot, and for commencing a regular series of exercises. In slight cases it is, of course, quite unnecessary, and indeed harmful, to place the foot at rest in plaster. It is much better to begin the exercises at once, and merely to take as much rest as can be had, either by sitting, or by standing in the way above mentioned.

*Exercises.*—To Mr. Ellis, of Gloucester, is undoubtedly due the credit of having impressed on the profession the importance of

exercises in the treatment of flat-foot. His numerous and interesting articles on the subject will well repay perusal. Mr. Ellis himself suffered from flat-foot of traumatic origin. After trying numerous supports and appliances, he at length completely cured himself by exercises alone. The exercises that he especially used are those now so universally known as the tip-toe movements. They have been employed during the last twelve years in nearly all the cases that presented themselves at the Orthopædic Department of St. Bartholomew's Hospital, and we share Mr. Ellis's enthusiasm in their use. When properly carried out and persevered in, we have no doubt that they are an immense aid both in relieving pain and in restoring the sunken arch. In slight cases in private they are often alone sufficient. Tip-toe exercises should be regularly and systematically performed. It is best to give specific instructions both as to how long and how often they should be done. As a rule, this should be five minutes at a time three, four, or five times a day; but the patient may advantageously, as opportunities offer, spring on to his toes from time to time whilst engaged in occupations necessitating lengthy periods of standing. We always tell the patient to stand opposite the clock, to rise and fall in regular rhythm with the swing of the pendulum, upright, in drill position, shoulders thrown well back, head up, arms by the side. In this way one obtains at the same time beneficial posture for the rest of the body. The feet should be slightly inverted, the heels somewhat apart, the knees kept well back, and where there is a tendency, as there often is, to knock-knee, at the moment of rising on the toes and separating the heels the patient should endeavour at the same time to force the knees apart. In all this there is a great deal of detail to be attended to; but unless the patient is shown how to do the exercises accurately, he will merely do them in a slatternly manner, and the same benefit is not gained. It is important that when the patient has raised himself up he should not remain standing on tip-toe, a fault he is apt to fall into if not specifically instructed to the contrary. As Mr. Ellis aptly puts it, it is the act of rising to tip-toe that does the good service. Standing on tip-toe or walking on tip-toe is more likely to do harm, in that the weight is again thrown on the stretched ligaments. Tip-toe exercises for children may be usefully modified in many ways.

Thus, a wheel or a coffee-mill may be fixed to the wall, with the handle placed eccentrically, so that at the upper turn the child has to raise himself on tip-toe, grasping, as it were, the ground with his toes to carry the wheel over. Or a weight may be passed over a pulley, and so arranged that when the weight is on the ground the child has to rise on tip-toe to reach the handle.

Tip-toe exercises have for their aim the strengthening of those muscles which, as we have shown in our introductory chapter,* are concerned in producing and supporting the arch of the foot; and of these, especially the long and short flexor of the great toe, for, as Mr. Ellis has so well shown, if the short flexor muscle which holds down the first, and the long flexor muscle which holds down the final phalanx of the great toe, be habitually in vigorous action, the other muscles which assist in holding up the arch (tibialis posticus and peroneus longus especially) will be pretty sure to be doing their part also.†

Holding as we do, therefore, the view that for the cure of flat-foot the muscles of the great toe especially should be brought into vigorous action, it necessarily follows that the movements of the great toe, whilst the exercises are being carried out, must have free play, and not be impeded by an improperly-shaped boot and stocking. Whilst the exercises are being actually done the feet should be bare; during the intervals a sock or stocking with a separate stall for the great toe, and a properly-shaped boot, should be worn (see Mechanical Treatment).

Tip-toe exercise should be combined with those to be next described.

*Circumduction of the foot*,‡ or winding round of the foot slowly at the ankle and subastragaloid joints, is another useful exercise. The movement consists of a combination of flexion and extension at the true ankle, and of rotation at the subastragaloid joint, by which the whole of the tendons around the ankle are successively brought into play. Whilst doing this exercise the patient should sit with the exercising leg crossed over the opposite knee, with the exercising knee straight, and the limb rotated inwards. After rotating the foot for some two and a half minutes in one

* Page 35.

† Ellis, 'Human Foot,' p. 54.

‡ Mr. Roth, I believe, was the first to write on this movement of the ankle-joint in the treatment of flat-foot.

direction, the motion should be reversed, and continued for the same time in the opposite direction. Patients have sometimes a difficulty in rotating the foot, being only able to flex and extend, and slightly abduct and adduct. When this is so, the motion must be imparted to the foot at first by the surgeon's or nurse's hands.

*Outer Edge Exercise—Standing or Walking on the Outer Edge of the Foot.*—It has already been said how much rest may be given to the arch by standing on the outer edges of the feet, with the inner edges of the soles of the boots propped against each other. The patient should stand with the feet nearly touching, and with the toes pointing a little inwards. In this position he should evert both feet so as to stand on their outer edges, and then immediately resume the plantigrade position. This alternately stand-


FIG. 270.—BOOT USED IN THE ORTHOPÆDIC DEPARTMENT OF ST. BARTHOLOMEW'S HOSPITAL FOR THE TREATMENT OF SLIGHT DEGREES OF FLAT-FOOT.

The dotted line indicates the thickening of the inner side of the sole within the uppers.

ing on the outer edge and on the sole of the foot should be continued for five or more minutes three or four times daily. Then, with the outer edge of the foot only on the ground, the patient may walk for the same period or less. The exercise, like the others, is best done without shoes and stockings.

*Foot-clothing in Flat-foot.*—In providing a rational clothing for the foot our aim should be as far as possible to impede as little as may be the natural movements of the joints, and especially to provide for freedom of function of the great toe. In the treatment of flat-foot these objects should be especially kept in view. A narrow-toed stocking or sock should be eschewed, and the broad-toed substituted for it, or, better, the stocking with separate

stall for the great toe, or the digitated stocking, with a separate stall for each toe. The boot should have a low heel, should lace


FIG. 271.—BOOT WITH TOE-POST. (Holden Brothers )
The upper toe-leather has been removed to show the position of the toe-post.

up, and the sole should be slightly raised on the inner side, so as to throw the foot slightly over to the outer side. The inner edge

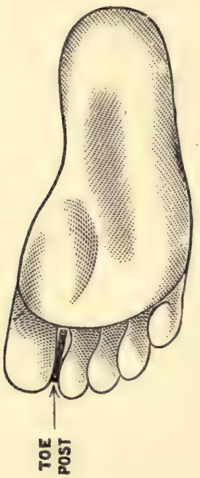



FIG. 272.—TO SHOW THE SHAPE THE SOLE OF THE BOOT SHOULD HAVE TO CORRESPOND TO THE SOLE OF THE FOOT. (Holden Brothers.)


FIG. 273.—TOE-POST (UPPER VIEW). (Holden Brothers.)

of the sole should be straight, or, better, slightly concave, with the concavity of the bow inwards, so as to allow for free play of

the great toe. The sole can be raised if desired inside the uppers, so as not to show externally (Fig. 270). The heel may in some cases be prolonged on the inner side, so as to give better support to the arch.

The toe of the boot should either be square or slightly sloped off on the outer side in correspondence with the slope of the small toes; but there should be no sloping on the inner side. A capital boot for flat-foot is manufactured by Messrs. Holden Brothers, in which in addition to the desiderata pointed out above, a septum or toe-post is placed between the great and second toe. By this contrivance any tendency to hallux valgus is combated, and freedom for the natural movement of the great toe is provided (see Figs. 271, 272, 273). The only objection that can be raised to the boot is its somewhat ugly appearance from the conventional point of view.

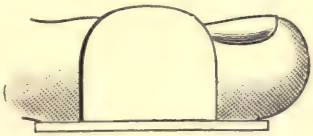



Fig. 274.—Toe-post (Lateral View). (Holden Brothers.)

The accompanying illustrations sufficiently explain the shape of the boot and the arrangement of the toe-post. The boot may be advantageously worn not only in flat-foot, but in hallux valgus, ingrowing toe-nail, etc.

**Manipulation and Massage.**—For severer degrees of flat-foot, where rigidity and spasm, though present, can be overcome by slowly and forcibly adducting and inverting the foot, manipulation and massage of the leg muscles is of great value. The foot should be grasped by the surgeon's hands in such a way that, whilst with the ball of the thumb he presses on the head of the astragalus, with the other hand he forcibly adducts, inverts, and plantar-flexes the fore part of the foot. In half a minute or so the foot gradually yields, and the deformity is reduced, though it may be, where there is much spasm, but slowly and with much pain. After each manipulation, however, the pain and spasm

become less, and suppleness is soon restored. Lorenz, on account of the pain, advises the injection of a few drops of 5 per cent. solution of cocaine into the neighbourhood of the calcaneo-scaphoid ligament. After this the foot is said to yield quite easily. Rédard speaks highly of the method. We confess, however, in the few cases we have tried, it was not very satisfactory, nor is it unattended with danger. Other surgeons have recommended the use of the ether or chloride of methyl spray for the same purpose. The manipulation should be repeated several times two or three times daily. Whilst the deformity is thus reduced, the foot may be circumducted and alternately dorsal and plantar flexed. Friction of the foot and leg with stimulating liniments, and massage of the leg muscles, especially the flexor longus hallucis, tibialis anticus and posticus, and short muscles of the sole, should be combined with the manipulation. Douching with cold water and electrical stimulation of the muscles will also be found of service. In short, our aim should be to promote in every way the tone of the muscles, which by their action produce and maintain the plantar arch, and counteract the tendency towards abduction of the foot.

**Mechanical Treatment.**—The mechanical treatment of flat-foot has for its object the supporting of the sunken arch and the correction of the valgus position. It may be considered under the heads of (1) bandaging; (2) boots and valgus pads; (3) elastic tension; (4) instruments.

1. *Bandaging.*—The application of a simple bandage over the foot and ankle is frequently resorted to by the laity for supporting, as they say, the arch of the foot, for strengthening the ankle, and for relieving the pain. For a time a bandage would certainly appear to give relief in some cases; but without more efficient means being taken, or the cause of the flat-foot removed, the relief is only temporary, and a severer grade of the deformity will sooner or later supervene. In very slight congenital cases, however, a properly-applied bandage, when combined with manipulative treatment, such as that described above, will suffice for the cure of the affection. Perhaps the chief objection to a bandage is that, if it is applied sufficiently tightly to have much or any effect in the correction of the deformity, it interferes with the circulation through the foot, so that further wasting of

the muscles will probably ensue. Whereas, in our view of ordinary static flat-foot, the whole aim of treatment should be to strengthen and brace up in every way in our power the muscles that support the arch and hold the foot in the normal position. A bandage, moreover, tends to make the foot more or less rigid, whereas free movement and pliability is desirable. If a bandage is applied, it should be put on from within outwards, so that at each figure-of-eight turn the direction of the pull is such that the foot is drawn towards the position of adduction and inversion. The bandage most commonly used in adults is Martin's rubber bandage. The objection to an ordinary bandage more especially applies to this form, since the compression is greater, and the circulation hence more interfered with. Further, it prevents the free escape of perspiration, and tends to cause eczema. For a time, however, we are bound to admit that it gives relief. If a bandage is used in congenital cases, it should be composed of domett, and should be removed twice or three times a day to allow of manipulative treatment being carried out.

2. *Boots, Valgus Pads and Surgical Soles.—Boots.*—For early cases a boot with the sole slightly thicker on the inner than on the outer side, with sometimes a valgus pad or surgical sole, is frequently employed in the Orthopædic Department. A description of the boot we advise has already been given under 'Foot-clothing,' p. 453.

*Valgus Pads.*—The valgus pad is an elongated, oval, wedge-shaped pad, so formed as to fit into the natural concavity of the plantar arch on the inner aspect of the foot. The pad is either fixed to the uppers of the boot in the proper situation, or merely worn loose in the boot. Its object is to give support to the sunken arch. The objection to its use is that it is unnatural and exercises injurious pressure on the ligaments and bones. As a palliative, however, whilst more radical means are being employed, it must be conceded that in some cases it gives great comfort, and undoubtedly helps in the cure of the affection by taking off the strain from the stretched ligaments. Valgus pads are made of various materials—felt, rubber, steel, leather, etc. The felt pad, made of superimposed layers of soft felt, somewhat after the manner of the graduated compress, is comfortable to wear and easy to make; but it soon becomes compressed, sodden

with perspiration, and hence hard and inefficient. The solid rubber pad is perhaps, on the whole, the most useful, especially in hospital practice. The rubber is a little hard and uncomfortable at first, but it soon becomes soft and pliable, and then exercises some elastic pressure on the sunken arch. A very good pad, but somewhat expensive, is the hollow rubber glycerine

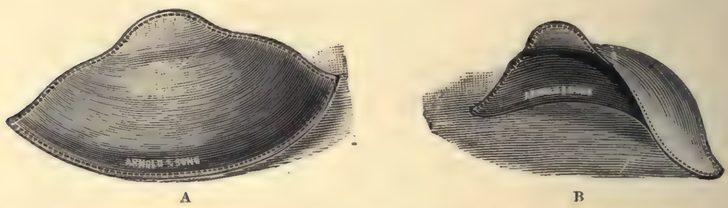



FIG. 275.—STEEL VALGUS PADS FOR THE TREATMENT OF FLAT-FOOT. (A) UPPER VIEW, (B) LOWER VIEW.

pad made for me by Messrs. Arnold and Sons. It is soft, pliable, very elastic, and exceedingly comfortable to wear, but is apt to break and allow the glycerine to escape into the boot. The steel pads (Fig. 275), though efficient at first, notwithstanding a covering of leather, rust from the perspiration of the foot, and then are apt to break across the most prominent part of their curve. On the whole, therefore, the rubber pad is perhaps the best for general use.


FIG. 276.—THE SURGICAL SOLE FOR THE TREATMENT OF FLAT-FOOT.

*The Surgical Sole* (Fig. 276).—This is a form of valgus pad. It consists of a leather sole resembling the well-known removable cork socks, with a steel piece shaped to the concavity of the normal arch of the foot let in on the inner side. It is a useful appliance, and in some respects more comfortable than the valgus

pad. The chief objection to it is that it takes up so much room in the boot, necessitating the wear of one or two sizes larger than the foot.

3. *Elastic Supports.*—Many forms of apparatus, some quite simple, others more or less complicated, have been devised for applying elastic tension to the sunken arch. When combined with efficient manipulative and gymnastic treatment, we hold that they are useful adjuncts. At the same time, however, we are most strongly of opinion that this treatment should not be trusted to alone. The elastic tension should not be allowed to take the place of the patient's own muscles, but should only be employed as a temporary expedient whilst the muscles, as the result of massage, exercises, etc., are regaining their strength and tone, and the overstretched ligaments are resuming their normal length.

Amongst the many forms of apparatus for applying elastic tension, we may mention the following:

*Barwell's Method of applying Elastic Tension.*—Mr. Barwell for this purpose applies a strip of tin along the inner side of the leg, and to this fixes elastic cords which are attached below to portions of strapping plaster applied beneath the sunken arch. The strip of tin is secured to the leg by strapping plaster and a bandage.

*Authors' Method of applying Elastic Tension.*—For many years past we have made use of a combination of elastic tension with a boot and leg-iron for severe degrees of flat-foot, especially where patients were unable to sufficiently carry out exercises, and where their occupation necessitated the continuance of long hours of standing. In a properly-shaped boot provided with an outside leg-iron and calf-piece (Fig. 277, A), a rubber band is fixed so as to exercise elastic tension on the sunken arch. The band is firmly secured to the upper leather inside the boot, along the outer border of the sole (Fig. 277, B), in such a position that, as it crosses under the sole of the foot, its centre corresponds to the middle of the calcaneo-scaphoid ligament. It is then carried up on the inner side of the foot to just above the top of the boot, and thence, through the medium of a leather strap and buckle, is secured to the calf-piece. A soft valgus pad can be slid over the rubber

strap, and be so adjusted that it corresponds, when in position, to the situation of the yielding arch.

4. *Instruments.*—Numerous instruments have been devised for the mechanical treatment of flat-foot. They may be divided into two classes, namely: (*a*) those employed for the correction of the deformity when the foot is held rigidly in the valgus position in consequence of ligamentous or muscular contraction, or muscular spasm; and (*b*) those employed for the purpose of supporting the arch, and holding the foot in the normal position, where there is

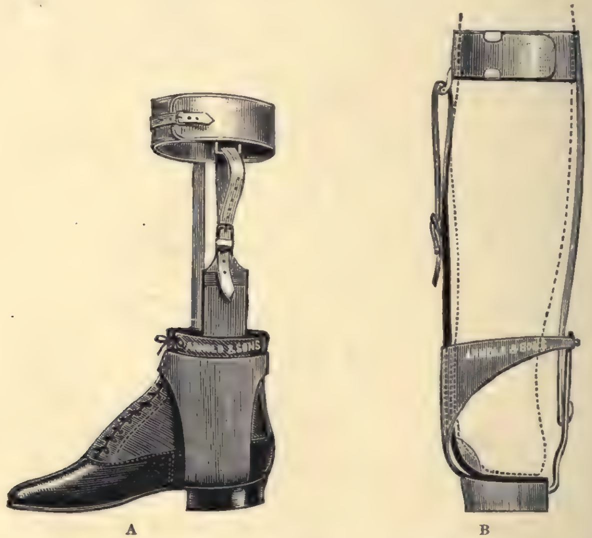



FIG. 277.—BOOT WITH LEG-IRON, T-STRAP, AND RUBBER BAND FOR APPLYING ELASTIC TENSION TO THE SUNKEN ARCH IN FLAT-FOOT. (A) VIEWED FROM INNER SIDE, (B) VIEWED FROM BEHIND.

no rigidity. The former necessitate the patient lying up; the latter may be looked upon as adjuvants to other forms of treatment, and allow the patient to stand and walk and follow his usual avocations.

We have had little personal experience of the purely correcting instruments, having, in cases where other surgeons employ them, almost invariably resorted to manipulation, or forcible correction

under an anæsthetic, and subsequent retention of the foot in the normal position by plaster of Paris.

(1) *Instruments employed for correcting the Deformity when there is Rigidity and Spasm.*—The instruments included under this class are practically modifications of Scarpa's shoe. They all consist in some form of slipper or sole-plate for holding the foot, and of a leg-iron or trough secured to the calf by circlets and buckles, the correction being accomplished by means of cog-wheels or springs corresponding to various centres of movement in the foot. They are all expensive, and for out-patients are

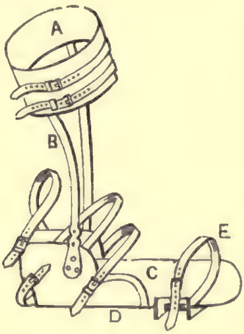



FIG. 278.—ADAMS' APPARATUS FOR TALIPES VALGUS OF MODERATE SEVERITY. (From Adams.)

A, circular band round leg; B, steel side-spring connected with the Scarpa's shoe, applied along the inner side of the leg, and having a cogwheel at its lower part corresponding to the ankle-joint; C, sole-plate; D, valgus pad attached to inner side of sole-plate; E, toe-strap attached to rectangular steel bar on inner side of sole-plate.

practically prohibitive. In our opinion, the work they are employed to accomplish is better done by wrenching under an anæsthetic, and the subsequent use of a plaster bandage.

The following, from amongst many, as those perhaps most used, may be described:

*Adams' Apparatus.*—For moderate degrees of severity, Mr. Adams uses the apparatus shown in Fig. 278. In this apparatus the eversion of the foot is controlled by the side-spring B, attached to the Scarpa's shoe, and adapted to the inner side

of the leg. The effect of this spring when the instrument is applied to the leg is to give the sole-plate, C, an oblique direction inwards, and then the valgus pad, D, attached to the inner side of the sole-plate, uplifts the arch of the foot. At the same time, the toe-strap, E, attached to a rectangular steel bar on the inner side of the sole-plate, has the effect of drawing the foot inwards, so that the whole foot when in the apparatus is inverted and arched over the valgus pad. The cogwheel opposite the ankle-joint is for stretching the tendo Achillis.

For extreme cases, where there is much muscular and ligamentous rigidity, he uses the apparatus shown in Fig. 279. The

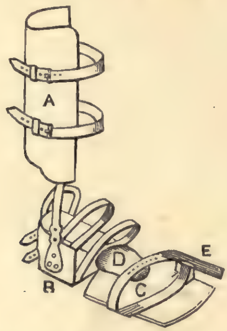



FIG. 279.—ADAMS' APPARATUS FOR THE MOST SEVERE CASES OF TALIPES VALGUS.

A, leg-trough ; B, heel-piece of shoe, with which the leg-trough is connected by a steel bar having a cogwheel placed opposite the ankle-joint on the outer side of leg ; C, movable anterior portion of sole-plate, the margins of which can be elevated or depressed by a cogwheel placed beneath the centre of the transverse joint in sole plate ; D, valgus pad attached to inner side of anterior portion of sole-plate ; E, toe-strap attached to rectangular steel bar fixed to inner side of sole-plate.

leg is placed in a trough, A, which is connected with the heel-piece of the shoe, B, by a short vertical steel bar, in which a cogwheel is placed, corresponding to the ankle-joint. The sole-plate is divided transversely at a part corresponding to the transverse tarsal joint, the anterior two-thirds, C, being made to move so that its inner or outer edge may be uplifted or depressed by a cog-wheel beneath. A valgus pad, D, is attached to the inner side of

the movable portion of the sole-plate. The anterior portion of the foot is drawn inwards by the toe-strap, E.

*Panas' Apparatus* (Fig. 281).—This apparatus consists of a metal shoe, the anterior portion of which moves on the posterior portion by means of a joint corresponding to the mediotarsal articulation of the foot, and of an outside lateral leg-iron, which can be fixed to the leg by two calf-circlets. The leg-iron is so fixed to the heel-piece of the shoe as to allow of three movements: (1) flexion and extension at the ankle; (2) elevation of the inner border of the foot; (3) adduction of the fore part of


FIG. 280.—ORDINARY VALGUS BOOT (LEFT).

the foot. To the movable part of the sole-plate of the slipper is fixed a valgus pad, corresponding to the plantar arch. The shoe is fixed to the foot by a broad strap and buckle.

(2) *Instruments employed as Adjuncts to other Treatment.*—These instruments allow the patient to follow his usual avocations, and should be regarded merely as aids to more radical methods of curing the deformity, such as exercises, etc. They may all be said to consist of a boot with an outside leg-iron, fixed to a calf-circlet, and having a T-shaped strap sewn to the welting on the inner side of the boot. The arms of the T-strap are buckled

round the outside iron. The T-strap, therefore, draws the sole upwards and inwards, forcing the prominent inner ankle towards the outside iron. The common valgus boot (Fig. 280) consists of little more than this, but has been improved in detail in many ways. The boot should be of a good shape—straight, or even

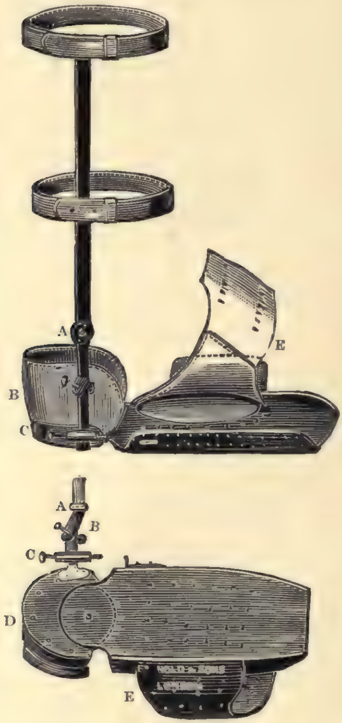



FIG. 281.—PANAS' APPARATUS FOR FLAT-FOOT. (From Rédard.)

A, tibial-tarsal joint; B, hinge and lever-screw for raising the internal border of foot; C, screw to draw anterior part of foot forward; D, mediotarsal joint; E, pad and strap fixed to inner border of shoe for holding up the arch.

slightly concave, along its inner edge, well squared at the toes, to allow of free play of the hallux and freedom of the smaller toes without crushing. It should be made of sound calf leather, and should lace up. The upper leathers of the boot should not

quite meet at first across the instep, so as to allow for the leather stretching in wear. The support given by the boot can thus be continually kept up by lacing tighter and tighter. The outside iron should extend up the calf to just below the head of the fibula,

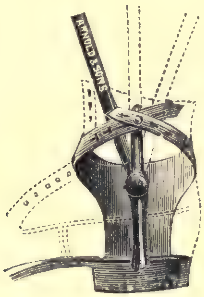


FIG. 282.—TO SHOW HOW THE T-STRAP SHOULD BE FIXED TO A PROLONGATION UPWARDS OF THE BOOT-IRON BEYOND THE ANKLE-JOINT IN ORDER THAT ONE OR OTHER ARM OF THE STRAP MAY NOT BECOME LOOSE IN THE MOVEMENTS OF THE FOOT AT THE ANKLE.

where it is riveted into a jointed calf-circlet, a band of malleable iron reaching from the outer iron round the leg. The circlet is padded and covered with leather, and buckles across the front of the leg. By having the iron calf-band malleable, it can be bent,

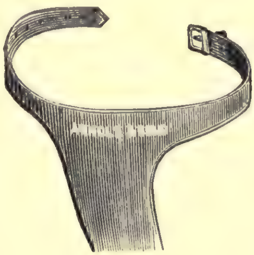


FIG. 283.—THE T-STRAP.

and so be better adapted to the shape of the calf. The outside iron should have a movable joint at the ankle, and be fixed below into the heel of the boot. The joint at the ankle should be free,

and so arranged that the boot, with the iron below the ankle, can be removed without taking off each time the leg-iron and calf-piece. This is easily managed by the combination of the round and square socket-joint, shown at p. 234: when the boot is unlaced and carried forward the joint slips; when standing upright, the hinge is fixed. It is an advantage to have the boot-iron carried up beyond the ankle-joint, as shown in Fig. 282, for an inch and a half or so, and at the upper end to have a button fixed for the two arms of the T-strap. The T-strap, if simply buckled over the outside iron, is never completely taut in walking; either, when the foot is extended, the front part is loose and the back tight, or, when the foot is flexed, the back part is tight and the front part is loose. But with the T attached to the prolonged boot-iron, in whatever position the foot may be, both arms are of course equally taut and doing their work. The T-strap (Fig. 283) consists of a piece of stout leather, shaped as shown in the figure, the arm being provided with a buckle if secured round the outside iron, or with holes if secured to the prolonged boot-iron. The lower end of the square part of the T-strap is firmly sewn into the inner side of the boot.

## Operative Treatment of Flat-foot.

Under this head will be discussed tenotomy of the peronei tendons and tendo Achillis, shortening of the plantar fascia, wrenching under an anæsthetic, ablation of the astragalo-scaphoid joint (Ogston's operation), the removal of the scaphoid, excision of a wedge from the neck of the astragalus (Stokes' operation), supra-malleolar osteotomy, etc.

With regard to the above methods, we may say that only once have we practised tenotomy of the peronei, and in this case we are under the impression the patient was not benefited by the operation. We have never divided the tendo Achillis, and we strongly hold that neither the peronei nor the tendo Achillis should be divided for ordinary static flat-foot. In congenital cases of what some would call talipes valgus, but which we prefer to call equino-valgus, the tendo Achillis, and at times the peronei, may be divided in some instances with advantage, but we are not discussing this condition here.

On one occasion only have we been driven to do Ogston's operation, and this was certainly not a success as far as relieving the patient of his pain and disability was concerned, though the wound itself healed admirably. On several other occasions we have had patients in the theatre for the purpose of performing some operation on the tarsus, but in every instance except that above mentioned we succeeded whilst the patient was under the anæsthetic in reducing the deformity by the method of wrenching. We have come to the conclusion, therefore, that it is only in an exceptionally small number of cases that a bone operation can be necessary, seeing that we have only once had to perform one out of a total number of cases reaching nearly fifteen hundred. We are aware that some surgeons have met with a different experience, and have frequently operated for flat-foot. We should like to know, however, if before the operation was undertaken an attempt was made to forcibly rectify the deformity with the patient deeply under an anæsthetic. Where there are advanced changes in the bones, such as we have described under the head of pathology, it is evident that little or nothing can be done by forcible rectification. But our contention is, and we hold that this contention is fully justified by the large experience we have had in the treatment of severe grades of the affection, that although the outward contour of the foot, and the extreme rigidity, may lead us to infer that advanced bone changes have occurred, these may not exist. Under an anæsthetic the deformity may be found to be due to little more than displacement of the bones, and the rigidity not to changes in the bones themselves, but merely to spasmodic and ligamentous contraction, conditions that may be overcome by force when the patient is deeply anæsthetized. In flat-foot following badly-set Pott's fracture, we have on several occasions had very good results from supra-malleolar osteotomy.

**Tenotomy.**—The division of the peronei, the extensor longus digitorum, the extensor longus hallucis, the tendo Achillis, and the tibialis anticus are by some surgeons recommended for the cure of flat-foot. In congenital cases, says Mr. Adams, 'the division of the peronei and extensor longus tendons may be sufficient; but the tendo Achillis frequently requires division, and in some severe cases it will be necessary to divide the tendons of the tibialis anticus and extensor hallucis muscles.' In

severe cases of some of the non-congenital varieties he also advocates tenotomy of some or most of the tendons above mentioned. The same appears to be the practice of many other surgeons.

For our own part, we practically never do tenotomy for either congenital or acquired flat-foot. We hold that the rigidity of the tendons is either the result of spasm of the muscles or of adaptive shortening due to the ends of the muscles having been approximated in the changed position of the bones. Further, we have invariably found that the contracted tendons yield readily to forcible rectification of the foot with the patient under the influence of an anæsthetic. A general account of tenotomy is given under Varus, at p. 184, and the methods of dividing the dorsal- and plantar-flexor tendons and tendo Achillis are there given. Here only need be described tenotomy of the peronei.

*Division of the Peronei Tendons.*—The peroneus longus and brevis may be divided where they lie behind the external malleolus, above the external annular ligament, or just behind the peroneal tubercle on the os calcis below the external annular ligament.

Behind the malleolus these tendons lie together, the long tendon upon the short, the latter being next the bone. They run vertically downwards in the groove behind the fibula, and then turn forwards and downwards across the outer side of the os calcis as far as the peroneal tubercle, where they separate, the shorter continuing forwards above the tubercle to its insertion into the base of the fifth metatarsal bone, the long passing deeply into the sole, where it runs in the groove on the front of the cuboid to the base of the first metatarsal bone. As far as the peroneal tubercle on the os calcis they are contained in a common fibrous sheath. At the peroneal tubercle the short tendon lies above the long, and here they enter distinct sheaths.

*Division of the Peronei above the External Annular Ligament.*—Both tendons can here be divided subcutaneously, by passing the tenotome beneath them and cutting outwards towards the skin, or, if preferred, by passing the tenotome between the skin and the tendons, and cutting through the latter towards the bone. Since there is no structure of importance in relation with the tendons in this situation, there can, in our opinion, be no reason for the open method recommended by some surgeons.

*Division of the Peronei below the External Annular Ligament.*—

Here both tendons may be divided together subcutaneously by passing the tenotome beneath them, as they lie on the side of the os calcis behind the peroneal tubercle; or the peroneus longus or brevis may be divided separately without disturbing the other tendon by passing the tenotome beneath it in front of the peroneal tubercle—the brevis as it runs to the base of the fifth metatarsal bone, the longus as it is dipping into the sole to enter the groove on the front of the under surface of the cuboid bone.

Cases of so-called congenital valgus, with shortening of the tendo Achillis, are classed by us as equino-valgus. For this deformity division of the tendo Achillis is necessary (see p. 335). Our remarks on the division of tendons in talipes valgus apply to pure valgus, not to cases of valgus with contraction of the tendo Achillis, *i.e.*, equino-valgus.

**Shortening of the Plantar Fascia and Muscles.**—Phelps,* who devised this operation, makes an incision across the sole of the foot, and through this incision hooks up the fascia and muscles, divides and shortens them, and then stitches them together; the skin is also shortened by removing a portion of it. The object of the operation is to shorten the 'girders' that hold up the arch. For slight cases, and, indeed, for all cases that admit of reduction by manual force, such an operation appears to us unnecessary; for severe cases, in which the bones cannot be forced back into place, it is clearly of no service. The division of the plantar fascia and muscles would seem to us to weaken them, and although, for a time, we can conceive it possible that the shortened ligament and muscles might resist the sinking of the bones into the flat-foot position, we cannot but think that the cicatrices would gradually stretch, and the deformity be worse than at first. In our view, the muscles that support the arch should be strengthened in every way; we do not think their division can promote this end. The portions of the muscles, moreover, in front of the division, in consequence of the interference of their nerve supply, we should imagine, would waste and atrophy.

**Forcible Rectification.**—This may be divided into manual and instrumental.

* 'Trans. Am. Orthop. Assoc.,' 1889, p. 137.

*Manual Rectification.*—The forcible rectification of the arch under an anæsthetic, and subsequently maintaining the foot in the restored position in a plaster of Paris case, is an excellent way of dealing with advanced degrees of the affection, where there is rigidity and the arch cannot be restored by ordinary manipulation without an anæsthetic. The credit of this method is due to my colleague Mr. Willett.*

Complete anæsthesia is necessary. Gas is insufficient. When

FIG. 284.—PHOTOGRAPH OF A FLAT-FOOT TREATED BY WRENCHING, AND SUBSEQUENT BANDAGING WITH PLASTER OF PARIS.

Note the extra thickness of plaster, which is put on at the heel so as to make the back of the plaster case level with the front.

gas is used, the spasm in the muscles is apt to return before the plaster case has thoroughly set, and the foot to resume the flattened condition. The surgeon, standing in front of the patient, takes hold of the foot with both hands, with the thenar eminence of one hand pressing on the prominent head of the astragalus, and whilst he thus presses the bone inwards, flexes, adducts, and inverts the front part of the foot, so as to bring it round, as on a pivot,

* 'St. Bartholomew's Hospital Reports,' vol. xviii., 1882.

at the subastragaloid and transverse tarsal joints. A distinct cracking, due to the breaking down of adhesions, is usually felt as the parts yield to the pressure and the arch is restored. The peronei, which before the manipulation are tense and prominent at the outer ankle, are now relaxed. The foot should next be twisted, first this way and then that, to thoroughly dispose of any remaining adhesions, and cased in a thick cotton-wool bandage, reaching from the toes to half-way up the calf. The plaster bandage should then be rolled on from within outwards, *i.e.*, in the opposite direction to that in which it is put on in the treatment of varus. Thus, starting on the inner side with a few

FIG. 285.—CASE OF FLAT-FOOT A YEAR AFTER TREATMENT BY WRENCHING, BY BOOTS FOR FIRST SIX MONTHS, AND BY EXERCISES.

The arch is seen to be slightly restored, and the foot is quite free from pain, and gives no trouble in any way. It was a very advanced case in the first instance, the inner edge of the foot forming a well-marked convexity.

turns round the leg, it should be carried over the ankle and outer side of the foot, and then up round the inner side of the foot in the form of a figure-of-eight. Each turn should be passed somewhat lightly over the outer side of the foot, and then drawn tightly as it is brought up over the inner side of the foot and ankle. In this way the foot is drawn by the bandage into a position of adduction and inversion.

Whilst the plaster bandage is being applied, the foot with the

arch restored should be held in a position of extreme adduction, inward rotation, and slight plantar flexion. The anæsthesia should be kept up till the plaster has become hard, otherwise, as the patient returns to consciousness, the foot may, in consequence of spasm of the peronei, be again drawn into the faulty position. With the foot in the position above described, it would be quite impossible for the patient to walk. To allow him to do so, a thicker layer of plaster should next be placed on the inner side of the sole, and a heel formed to the plaster case. The thickening of the inner side of the sole and depth of the heel should be such that the plane of the bottom of the plaster case may be at right angles to the leg. To judge whether sufficient has been done in this direction, a piece of board should be applied to the sole of the plaster case, and more plaster applied if the board, when held at a right angle to the leg, does not touch the plaster on the inner and back part of the foot. The thickening of the inner side of the sole is easily accomplished by applying wet strips of crinoline soaked in the plaster. The heel may be made by flattening out one of the plaster rollers and fixing it with a turn or two of the plaster bandage. The bottom of the heel should be left broad, that the patient may have a wide basis of support. If the plaster is well applied, the patient will be able to walk in it quite comfortably, and without pain. He should not attempt to do so, however, as a rule, for twelve hours, and certainly not till the plaster case has got thoroughly dry. The usual attention should be paid to the circulation through the foot and toes as after the use of plaster bandages in other situations. Cotton-wool is better than a flannel or domett bandage, but it must be properly applied—smoothly wound on in bandage form—a mass simply put on anyhow, so as to cover the foot, is liable to work into hard lumps, and to prevent equalization of the pressure.

The plaster should be worn for about a month. At the end of that time the patient will, in all ordinary cases of moderate severity, be ready for a surgical boot and exercise. In severe cases it may be advisable, if the arch is not completely restored at the first wrenching, to repeat the operation and place the foot in plaster of Paris for another month. A third manipulation is seldom required, but should at the same

time be resorted to if the bones are not yet quite satisfactorily in place. This method has been in constant use in the Orthopædic Department for the last eleven years. Several of the cases were so severe that they were taken into the theatre for some bone operation; but under deep anæsthesia the foot yielded to pressure, and beyond placing it in plaster, as above described, nothing further was required. We cannot help thinking that if before undertaking a bone operation manipulation was tried, many operations would not be done.

*Forcible Instrumental Rectification* may be done by Thomas's wrench, or one or other of the instruments employed in the treatment of talipes varus, and described at p. 173. We have not employed this method ourselves, because we have found that rectification under an anæsthetic with the hand has been sufficient.

**The Ablation of Chopart's Joint (Ogston's Operation).**—The objects of this operation are (1) to denude as much of the cartilaginous surface of the astragalo-scaphoid joint as possible; (2) to place the foot in the proper position, and (3) to secure immobility by pegging the bones together. This operation has been performed many times by Professor Ogston, and is spoken of by him as highly successful in relieving both the pain and deformity. It has also now been employed by other surgeons, and by some is said to have been of considerable service, and to have practically relieved the patient. As before stated, we have only once had occasion to perform the operation ourselves, and in this case the result was disappointing. The patient still suffered considerable pain on attempting to use his foot, and when last heard of, several years after, was still in a miserably crippled condition. We have also met with another patient in the Orthopædic Department who had had this operation performed by an able surgeon at one of the other London hospitals, and he, too, had experienced no relief. In our own patient it was months before he was able to put his foot to the ground. The gravest objection, perhaps, to the operation is that it aims at immobilizing portions of the tarsus, which should, normally, move freely on each other, and thus renders the inner side of the foot rigid. It cannot, therefore, be called in any sense a cure. Indeed, Professor Ogston, we believe, does not claim such for it, since a flat-foot can only be

said to be cured when the normal suppleness of the joints has been restored and the sunken arch raised. If, however, the patient, by means of Ogston's operation, is relieved of his pain, and is thus enabled to follow his occupation, the mere fact of the rigidity of the inner side of the foot is, of course, of little account. Dr. Ogston's reports are so encouraging, and the suffering and disability caused by flat-foot in its severest grades are so great, that, notwithstanding the unfavourable experience we have so far had of the operation, we should certainly, in such cases as do not yield to forcible rectification, give it further trial.

*The Operation.*—The foot, having been thoroughly prepared for an aseptic operation, the patient anæsthetized, and an Esmarch's bandage applied, is laid on its outer side, and thus firmly held by an assistant, who should not, however, according to Professor Ogston's directions, make any attempt to reduce the deformity.*

The surgeon, standing on the left of the patient, makes an incision 1·25 inches long, and parallel to the sole along the inner side of the foot over the astragalo-scaphoid joint. The posterior end of the incision should begin about an inch from the tibia, so that the centre of the incision may be over the joint. All the soft tissues are divided down to the bones. The head of the astragalus having been exposed, free access to the joint is obtained by separating the attachments of the ligamentous capsule to the edge of the scaphoid, for a distance of half an inch on each side of the wound. The connections of the ligaments with the periosteum and fibrous structures over the scaphoid are spared as much as possible by cutting with the edge of the scalpel directed towards the toes, its blade lying parallel with the bone. Thus a T-shaped opening is made into the joint. A stout chisel, half an inch broad and bevelled on one side, is applied with the straight side to the head of the astragalus, and the articular cartilage and a thin layer of bone is removed by it from the whole exposed surface of the astragalus. The chisel is next applied to the scaphoid with the

* In several cases in which we had intended to perform Ogston's operation, we disregarded this injunction, and found, we confess somewhat to our surprise, that on attempting to reduce the deformity the bones, after the giving way of some ligamentous contractions, went fairly back into place. It is needless to say the operation was abandoned, and the foot placed in plaster. The patients ultimately obtained a useful foot without any further operation.

bevelled side towards the bone, so as to denude the bone and leave a concave surface.

In severe cases the prominent angle on the lower surface of the head of the astragalus must also be shaved off. The joint is now washed out and an attempt made to restore the foot to the normal shape by depressing the metatarsus. Whilst the foot is held in the restored position, holes are drilled through the scaphoid into the astragalus. The point of the drill, which should be somewhat smaller in size than the pegs to be employed, is placed on the upper and inner side of the scaphoid and directed towards the centre of the head of the astragalus, and should be made to perforate about an inch and a quarter through the two bones. The ivory peg is next driven home by a series of light taps with a mallet. A second peg is then inserted in the same way parallel to the first, and about half an inch distant from it. Whilst the pegs are being put in, the skin should be retracted by an assistant —since one perforation will be under the upper margin of the wound, and the other under the lower margin. The wound is closed, an antiseptic dressing applied, and the foot and leg secured in plaster of Paris. If all goes well, the dressing may be left undisturbed for several weeks. Professor Ogston recommends that the patient should be kept in bed for two or three months, and should not be allowed to walk for at least three months. In some of his cases there was slight tenderness on trying to walk at the end of six or eight weeks. In most of his patients bony ankylosis and a painless arch was the result, and they were enabled to resume their laborious occupations. In a few the plantar arch was restored to perfection, but this was not the general result, though the arch was much improved.

*Hare's Modification of Ogston's Operation.*—Mr. Hare has modified Ogston's operation by cutting the scaphoid and astragalus in such a manner that after the operation they interlock. The bones are exposed through an incision on the inner border of the foot, two inches in length, and parallel to and immediately below the tendon of the tibialis posticus.* The anterior and lower part of the displaced astragalus and the posterior part of the scaphoid are removed slice by slice with Macewen's chisel, in such a manner that when the astragalus is pressed upwards and the scaphoid

* Hare, *Lancet*, Nov. 9, 1889.

downwards the bones dovetail with each other, the arch being restored. The periosteum of the one bone is sewn to that of the other by catgut sutures. This operation differs from Ogston's in that the bony surfaces are cut in a zigzag manner, so that they may support each other, and not require ivory pegs for that purpose. The introduction of the pegs has in some instances led to the splitting of the bones and considerable trouble in the after-treatment. Hare placed the foot, n his case, on a Dupuytren's splint. On leaving the hospital, seven weeks after the operation, the patient could walk easily and without pain. This operation is a very ingenious modification of Professor Ogston's, and in severe cases that cannot be reduced under an anæsthetic, would appear worthy of further trial. It is, however, of course, open to the same objection as Ogston's—that it leaves the patient with a rigid astragalo-scaphoid joint.

**Removal of the Scaphoid.**—The removal of the scaphoid with, in some instances, a portion of the astragalus, has been practised, amongst others, by Richard Davy and Golding Bird for intractable cases of flat-foot. The objects of the operation are: (1) to remove a wedge on the inner side of the foot, and so restore in some measure the arch, the pain being relieved by the removal of pressure. Golding Bird operated in four cases; in all the pain was relieved, but in only one was the arch in any way restored. In this case, besides removing the scaphoid, he sawed subcutaneously across the whole tarsus, and adducted and rotated the front upon the back part of the foot. In one case only the scaphoid was removed, and in two that bone and the head of the astragalus as well.

In writing in 1888, Bird says he has not performed any operation on the tarsus for flat-foot for eight years, and he attributes this fact to the better use he has made of springs, elastic tension, etc.

**Excision of a Wedge of Bone from the Head and Neck of the Astragalus (Stokes' Operation).**—Sir William Stokes, viewing the deformity in severe cases as consisting chiefly in an alteration in the shape of the astragalus, removes a wedge-shaped piece from the head and neck of that bone.

This is no doubt a step in the right direction, but unfortunately in all cases is not sufficient to restore the shape of the arch and relieve the crippling and pain.

*Operation.*—The foot having been prepared for an aseptic operation, and the patient placed under an anæsthetic, the surgeon makes an incision about an inch and a half in length, having its centre over the prominence caused by the astragalus. The incision should be a little below, and parallel with, the tendon of the tibialis posticus. A second incision is then made at right angles to the first, a little behind the astragalo-scaphoid joint. The two triangular flaps are now dissected back for half an inch, exposing the bone. A wedge-shaped piece is next chiselled out from the head and neck of the astragalus with an osteotome. The arch of the foot in Sir William Stokes' cases could now on adduction and rectification of the foot be completely restored. A Dupuytren's splint is used by Sir William Stokes, but a plaster of Paris bandage would of course do equally well.

**Transplantation of the Posterior Part of the Os Calcis (Gleich's Operation)**.—Gleich, in order to raise the posterior pier of the arch, makes an oblique section through the posterior part of the os calcis, and having divided the tendo Achillis, slides the excised fragment forwards and downwards, and fixes it in that position. To expose the os calcis, he makes an incision from one malleolus to the other across the sole, similar to that in Pirogoff's operation. The effect of this operation would probably be, as pointed out by Sir William Stokes, to raise the heel, and thus lead to troubles similar to those that follow the wearing of high-heeled boots.

**Cuneiform Resection of the Tarsus (Larabrie's Operation)**.—Larabrie removed the whole of the scaphoid, the head of the astragalus, a portion of the internal cuneiform, and a corner of the cuboid for severe congenital valgus in a patient aged seventeen. The deformity was extreme, the sole being convex, the dorsum concave. Division of the extensors, peronei and tibials failed to correct. The bones, after the deformity was rectified, were united by wire suture. The result was a useful foot, and a plantigrade condition.

**Supra-malleolar Osteotomy**.—This operation, which has been somewhat extensively practised in Germany and in the United States, consists in cutting across the tibia and fibula just above the ankle-joint subcutaneously, and then forcing the foot into as

fairly normal a position as possible. The operation appears to have been first done by Trendelenburg, who, having observed the improvement brought about by supra-malleolar osteotomy in the valgus distortion, unfortunately of not such infrequent occurrence as the result of badly-set Pott's fracture, was led to believe that equally good results might follow a division of the leg-bones just above the malleoli in static and other acquired forms of flat-foot. In both the Pott's fracture and flat-foot the foot has no doubt a valgus position, but here it may be said the analogy ceases. In Pott's fracture the displacement is at the true ankle-joint; in flat-foot at the subastragaloid joint. In the former the malleolar fragment of the fibula is everted at its lower end, and either the internal malleolus is broken off, or the internal lateral ligament torn. In the latter both the leg-bones are intact. In the description of the cases where supra-malleolar osteotomy has been done for the cure of flat-foot, it is generally stated that after the bones have been subcutaneously divided the foot was forcibly wrenched into its restored or slightly over-restored position, and then secured in plaster of Paris. Arguing from what we venture to call the exceptional experience we have had at St. Bartholomew's of what can be done by wrenching alone, and even in very advanced cases of flat-foot, we cannot help feeling that after all it was possibly to the wrenching and consequent yielding of the tarsal bones at the subastragaloid joint, and not to the division of the leg-bones, that most of the good obtained in the cases quoted was due. And one is inclined the more to this view, since it is stated in some of the accounts of the operation that after the osteotomy and wrenching, the foot formerly, rigid, became quite supple before it was encased in the plaster of Paris. It is difficult to understand how the transverse severance of the tibia and fibula above the ankle could well affect the rigidity of the foot at the subastragaloid joint. It might, perhaps, be argued that the osteotomy got rid of the contraction of the peronei; but if this is the only gain the operation is unnecessary, since under chloroform these muscles can always be made to yield by forcing the foot inwards, or even, if this is not sufficient, a tenotomy of these tendons would certainly be enough. Where, however, the rigidity and displacement at the subastragaloid articulation has become permanent, in consequence of overgrowth

of bone at Chopart's joint, the carrying inward of the whole foot at the line of the division of the leg-bones will no doubt to some extent restore to outward appearances the shape of the foot, and may possibly relieve the pain and improve the patient's power of walking; but it certainly does not touch the root of the evil. To attack this some operation on the region of Chopart's joint would seem to be required.

From these considerations we cannot commend supra-malleolar osteotomy as a rational method of dealing with the deformity. We are not altogether without practical experience of the operation, having once performed it on a very severe case of valgus without rigidity, but in which the foot could not be restored either by force under chloroform, or after division of the peronei. The bones below the astragalus had been, in consequence of the disproportionate growth of two inches in the length of the legs, displaced so far outwards that the internal malleolus came in contact with the ground. After division of the tibia and fibula the foot could be sufficiently inverted to allow of a valgus instrument being worn. With the aid of this, and a high boot for the opposite leg, the lad was enabled to walk and even run exceedingly well; but to say that the flat-foot was cured would be absurd. The displacement at the subastragaloid joint still remained; the bending inward of the tibia and fibula at the line of the osteotomy merely allowing the sole of the foot to come in contact with the ground, and permitting of a straight iron, hinged at the ankle, to be worn for the purpose of holding the foot as far as it would go towards the corrected position. Before the operation the angle formed by the foot and leg at the outer ankle, with the foot inverted as much as possible, was too great to admit of the adaptation of irons.

*The Operation.*—The parts having been rendered aseptic, a vertical incision, half an inch in length, and down to the bone, should be made two inches above the tip of the internal malleolus, about midway between the tibialis anticus and posticus; the osteotome having been introduced through the incision, and turned transversely to the tibia, the bone should be divided by a series of blows from the mallet, care being taken whilst dividing the posterior surface of bone which is in contact with the posterior tibial artery to hold the chisel vertical to the internal

surface of the tibia. A chisel with a rounded end is used, and if care is taken not to direct its cutting edge in the slightest degree backwards, and thus not to allow it to penetrate beyond the posterior surface of the tibia, the posterior tibial artery should remain safe. Whilst dividing the anterior surface, the point of the chisel should be directed slightly backwards, to avoid the anterior tibial artery. Having completely divided the tibia, or as completely as is deemed safe, and placed over it a temporary antiseptic dressing, the fibula should be next attacked from the outer side of the limb, through a vertical incision half an inch in length and two inches above the tip of the external malleolus. The fibula having been freely divided, and the wound closed with a dossil of antiseptic gauze, the surgeon grasps the bones above and below the incision. If the tibia has been sufficiently severed it will now readily crack across ; if it does not yield, the osteotome must be reintroduced. The foot with the lower fragments should be now brought as near as may be into the normal position, and an antiseptic dressing having been firmly applied, and the foot and lower two-thirds of the leg placed in a cotton-wool bandage, should be secured in plaster of Paris. We do not, after division of the tibia and fibula, advise any wrenching. This in our opinion should always be done before the cutting operation is employed. If the foot will yield after the osteotomy it will yield before; the more serious procedure will hence be rendered unnecessary. If proper precautions are taken to keep the wound aseptic, the plaster of Paris bandage may remain on for a month or five weeks. On its removal the incisions should be found healed and the bones consolidated. It will be then well to reapply the plaster for a month or two.

## Treatment applicable to the Various Degrees of Ordinary Static Flat-foot.

**First Degree, or Incipient Stage.**—In these slight cases rest combined with proper exercises and corrected methods in walking and standing, together with rational clothing for the foot, will soon effect a cure. Shampooing and massage may be advantageously associated with the above—in fact, everything that tends to promote the tone of the muscles of the calf and foot.

In some cases the boot described at p. 453, with or without some form of valgus pad or surgical sole, may be worn in addition.

**Second Degree, or Pronounced Flat-foot.**—In this degree rest should be a more prominent feature than in the first, and the manipulations described at p. 455 should be practised twice or thrice daily till all rigidity has disappeared. The treatment recommended for the first degree should then be employed, and if the patient has still to follow a laborious occupation, or one necessitating long standing, the author's elastic tension apparatus (p. 460) will be found of considerable service. As in the majority of hospital cases it is difficult, if not impossible, to obtain the requisite amount of rest, and to ensure the efficient carrying out of the exercises, it is generally necessary to order from the first some form of mechanical apparatus such as the above, or one of those described under mechanical treatment, so as to allow the overstrained ligaments and muscles to regain their tone. In some instances it may be of advantage to place the foot in the restored position in plaster of Paris in the way described at p. 469.

The surgeon, when ordering a support, should be careful to insist upon the exercises when possible being thoroughly carried out and faults in standing or walking corrected, for patients are too apt to rely solely upon the mechanical support, and so are only relieved and are not cured of their flat-foot, and a relapse soon occurs.

**Third Degree, or Advanced Flat-foot.**—In this degree the foot should be wrenched under an anæsthetic, and placed in plaster of Paris, as described at p. 469. When the bones are held in the deformed position by spasm of the peronei, the foot readily yields as soon as the patient is brought fully under the anæsthetic; but when due to adhesions, considerable force may have to be employed, and the wrenching repeated on the removal of the plaster case. In some instances, even after repeated wrenchings, the arch may not be completely restored, although the pain and disability are relieved. As soon as the rigidity has disappeared under this treatment the case may be treated as described under the second degree, and if improvement is still progressive, as described under the first.

**Fourth Degree, or Intractable Flat-foot.**—In this degree, which

includes the most severe grades of the deformity, the arch cannot be restored by manipulation under an anæsthetic, owing to alteration in the shape of the bones. We have then either treated it palliatively by a boot and instrument, and in this way have succeeded in relieving to a great extent the pain and discomfort in standing and walking, or we have resorted to Ogston's operation, or supra-malleolar osteotomy.

## Modifications of Treatment required for Certain Varieties of Flat-foot.

**Congenital Flat-foot.**—For slight cases of true congenital flat-foot, and by this we mean cases in which there is neither equinus nor calcaneus (for which see Equino-valgus and Calcaneo-valgus, pp. 321, 385), manipulation and placing the foot in the rectified position in plaster will, as a rule, suffice. Later, exercises, massage, and a boot with valgus-iron and T-strap may be required.

**Paralytic Flat-foot.**—The treatment here can only be palliative; the paralyzed muscles cannot of course be restored, though even in severe cases something may be done by electricity and massage to bring such portions of the muscles as have not undergone actual structural degeneration into use. If the foot can be readily replaced, all that will be required is an instrument to hold it in the normal position, the valgus and eversion being overcome in the way described at p. 463. When the paralysis involves the thigh muscles, the outer iron should be carried to a pelvic girdle, and if the knee is weak, the joint at the knee should be provided with a ring-catch or other arrangement for fixing it and rendering it rigid during extension.

**Rheumatic Flat-foot.**—In this form the ordinary constitutional treatment of rheumatism—the salicylates in the earlier stages; the iodide of potassium, bicarbonate of potash, lemon-juice, etc., in the later, in conjunction with the dietetic and hygienic treatment appropriate for rheumatism—will be necessary, as well as local measures. The latter consist in rest, where there is much pain, the application of glycerine and belladonna, and the like. For the effusion around the ankle, we have found strapping with ammoniacum and mercury plaster of great benefit. Later, when the effusion has been got rid of, we either first place the foot in

plaster of Paris for a month or two, or at once treat the case as one of ordinary static flat-foot, that is, by exercises, massage, etc., and the use of a boot. In the gonorrhœal form, in addition to the above treatment, the gonorrhœa, if the discharge still continues, must be combated by appropriate remedies for that malady. This variety of rheumatic flat-foot is often intractable. For the pain so often felt at the insertion of the tendo Achillis

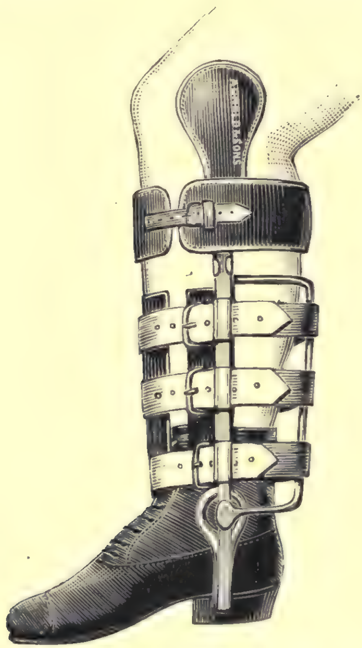


FIG. 286.—TIBIAL IRON FOR THE TREATMENT OF CURVED TIBIÆ.

and plantar fascia into the os calcis, some form of mercurial ointment may be applied.

**Rachitic Flat-foot.**—In the rachitic form, cod-liver oil, and syrup of the phosphate of iron and lime, are indicated, together with proper dietetic and hygienic treatment. For the flat-foot which is frequently combined with bowed tibiæ and knock-knees, or both, the child, if the bones show any spring, should be taken com-

pletely off its feet for three to six months. For this purpose, in the Orthopædic Department, we apply long splints reaching from the waist to two inches below the boots. In this way the tibiæ will grow as a rule straight, and the flat-foot disappear. Or if it is considered undesirable to take the child completely off its feet, the boot and inside tibial iron, shown in Fig. 286, may be employed. The iron is fixed in the boot by a round socket, and has no joint corresponding to the ankle, the round socket allowing of dorsal and plantar flexion. The iron above is fixed to a calf-circlet, and by means of the expanded portion shown in the figure, takes its bearings from the internal condyle. The spring seen at the lower end of the iron prevents injurious pressure on the external malleolus. Force is brought to bear on the outwardly curved tibia by means of the transverse calf-straps, which pass over a thick leather plate applied over the tibia and through slots in the iron. Circular constriction is prevented by means of the steel bar fixed by its two rectangular ends to the upper and lower part of the leg-iron.

In later cases, where the bones of the leg show no tendency to yield, but are consolidated in the bent position, an osteoclasia for the bow-legs or knock-knee will generally have to be performed, and subsequently any flattening of the foot that may remain may be treated on the lines laid down for the ordinary static form. Where the bending of the tibia is extreme, an osteoclasia may not be sufficient to correct the bone, and an osteotomy and the removal of a wedge-shaped piece from the most prominent part of the curve of the tibia will be required.

**Traumatic Flat-foot.**—For the ordinary traumatic flat-foot, viz., that attributed to a sprain, the treatment recommended for static flat-foot will, as a rule, suffice. In those cases, however, in which there is a clear history of the deformity coming on immediately or very soon after the injury, rest with the foot in the restored position in plaster should be enjoined for some months, to allow the ligaments time for repair ; then exercises, with manipulation and massage, should be perseveringly carried out till the cure is complete.

Where the flat-foot is the result of a badly-set Pott's fracture, wrenching of the foot, with division of the tendo Achillis if necessary for the purpose of improving the valgus, should first be

employed. This failing to accomplish the desired end, a supra-malleolar osteotomy, or, in some instances, an osteoclasia in this situation, may be required. The operation usually done is division of the fibula. We have not found this, however, always sufficient for rectifying the deformity. The tibia should then also be divided by the osteotome. In two cases recently under the care of Mr. Walsham, he divided not only the tibia and fibula, but removed a wedge-shaped piece from the internal malleolus, with the base inwards. The foot, after the removal of the wedge, was

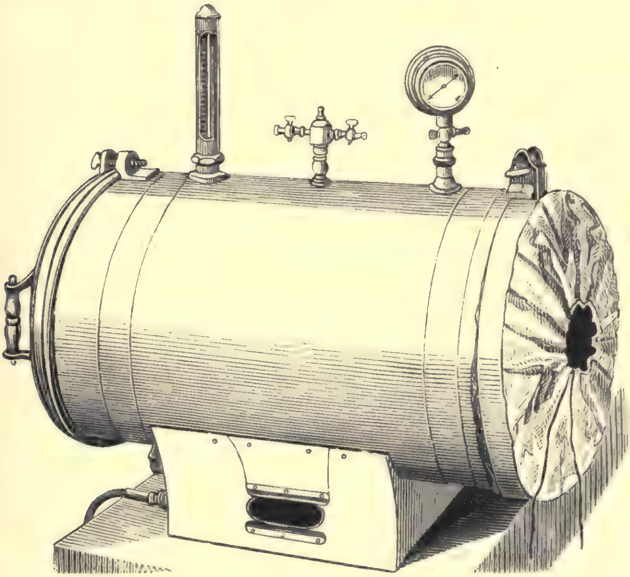


FIG. 286A.—THE TALLERMAN AND SHEFFIELD LOCALIZED HOT-AIR BATH.

brought into excellent position—the valgus being completely overcome—and in this position was secured in plaster of Paris, without changing the dressing till the wound had healed and the bone firmly united. The result in both cases was satisfactory in every way.

**Constitutional Treatment of Flat-foot.**—In some cases no constitutional treatment is indicated. In the majority of cases, however, of static flat-foot, a tonic treatment combined with general

and hygienic treatment for the improvement of the muscular tone is desirable. Iron in some form is generally useful. In the rachitic, cod-liver oil with the syrup of the phosphate of iron should be employed ; in the rheumatic, the salicylates and iodide of potassium ; and in the gouty, colchicum, lithia, piperazine, etc.

**Treatment of the Third or Rigid Degree of Flat-foot by the Hot-Air Bath.**—Since writing the treatment of flat-foot we have, instead of giving an anæsthetic, placed the rigid foot in the Tallerman and Sheffield hot-air bath (Fig. 286A), in order to produce relaxation of the adaptively-contracted muscles and ligaments. In several cases in which the foot was held rigidly abducted, with the bones displaced in the way characteristic of the severe degrees, and in which, moreover, the bones could not be forced back by manipulation with the unaided hands, we found that after the foot had been three-quarters of an hour in the bath at a temperature of about 300° Fahr., it came out quite supple, so that without any force the bones could be replaced and the arch restored. The foot was then in some instances put in plaster of Paris in the adducted and plantar-flexed position for the usual time, and in other instances a boot or boot and iron was ordered, and exercises begun.

## Statistics of Flat-foot.

The following statistics were compiled by Mr. Kent Hughes from the volumes of bound out-patient orthopædic letters for ten years, from 1882 to 1893 inclusive. The statistics, however, only embrace those cases actually treated as out-patients in the Orthopædic Department, not those that were admitted directly under Mr. Walsham's care into the wards of the hospital, nor those presenting themselves on his ordinary out-patient days, nor the patients with flat feet who have been under the care of the other surgeons, either as in- or out-patients. The numbers given, therefore, do not represent anything like the number of cases of flat-foot treated at the hospital.

During the ten years 1882-1893 there have been 1,078 cases of flat-foot treated in the Orthopædic Department; of these 703 were males, 375 females. Both feet were affected in 547 cases; the right foot alone in 156 ; the left foot alone in 154. In 221 cases the note does not state whether one or both feet were flat.

TABLE OF AGES AT WHICH FLAT-FOOT WAS DEVELOPED.

| Age. | Cases. | Age. | Cases. |
|---|---|---|---|
| 2 years and under | 29 | 31 years ... ... | 6 |
| 3 years ... ... | 16 | 32 ,, ... ... | 16 |
| 4 ,, ... ... | 10 | 33 ,, ... ... | 7 |
| 5 ,, ... ... | 7 | 34 ,, ... ... | 7 |
| 6 ,, ... ... | 13 | 35 ,, ... ... | 5 |
| 7 ,, ... ... | 9 | 36 ,, ... ... | 9 |
| 8 ,, ... ... | 9 | 37 ,, ... ... | 4 |
| 9 ,, ... ... | 10 | 38 ,, ... ... | 3 |
| 10 ,, ... ... | 31 | 39 ,, ... ... | 6 |
| 11 ,, ... ... | 34 | 40 ,, ... ... | 6 |
| 12 ,, ... ... | 58 | 41 ,, ... ... | 3 |
| 13 ,, ... ... | 96 | 42 ,, ... ... | 5 |
| 14 ,, ... ... | 109 | 43 ,, ... ... | 4 |
| 15 ,, ... ... | 105 | 44 ,, ... ... | 3 |
| 16 ,, ... ... | 84 | 45 ,, ... ... | 2 |
| 17 ,, ... ... | 57 | 46 ,, ... ... | 3 |
| 18 ,, ... ... | 45 | 48 ,, ... ... | 2 |
| 19 ,, ... ... | 32 | 49 ,, ... ... | 2 |
| 20 ,, ... ... | 21 | 50 ,, ... ... | 1 |
| 21 ,, ... ... | 19 | 52 ,, ... ... | 2 |
| 22 ,, ... ... | 14 | 53 ,, ... ... | 2 |
| 23 ,, ... ... | 24 | 54 ,, ... ... | 2 |
| 24 ,, ... ... | 20 | 55 ,, ... ... | 2 |
| 25 ,, ... ... | 11 | 58 ,, ... ... | 1 |
| 26 ,, ... ... | 14 | 59 ,, ... ... | 1 |
| 27 ,, ... ... | 18 | 60 ,, ... ... | 1 |
| 28 ,, ... ... | 16 | 62 ,, ... ... | 3 |
| 29 ,, ... ... | 8 | 63 ,, ... ... | 2 |
| 30 ,, ... ... | 5 | No age stated in note | 44 |
| | | Total | 1,078 |

In 71 cases effusion into the tendon sheaths and surrounding tissues, especially about the inner ankle, was noted. In 29 cases the flat-foot was associated with genu valgum. In 44 cases

there was marked hallux valgus. In 7 cases lateral curvature of the spine was noted.*

In 95 cases the flat-foot followed an attack of rheumatic fever; in 14 cases some other acute fever; in 5 cases gonorrhœal rheumatism. In 89 cases the flat-foot was attributed to a sprain cr other injury of the foot. In 30 cases of patients over 10 years of age there was a history and past signs of rickets. All the cases under 10 years of age (103) were due to rickets except 7. Of these 7 cases 2 were due to incapacity of the other foot, 2 followed on acute fever, and 3 were attributed to sprain.

Out of the 1,078 cases, 95 were attributed to rheumatic fever = less than $\frac{1}{11}$th. Out of the 208 cases between the ages of 24 and 63 inclusive, 34 were attributed to rheumatic fever = $\frac{1}{6}$th.

Out of 1,078 cases, 89 were attributed to a sprain = $\frac{1}{12}$th. Out of the 208 cases between the ages of 24 and 63 inclusive, 24 were attributed to a sprain = $\frac{1}{8}$th.

Out of 1,078 cases, 211 were due to rheumatic fever, other fevers, sprain, gonorrhœa, and incapacity of the other foot = $\frac{1}{5}$th. Out of the 208 cases between the ages of 24 and 63, 69 cases were due to one or other of the above = $\frac{1}{3}$rd of the cases. Thus, it will be seen that nearly twice as many cases above the age of 23 had one of the above predisposing causes.

There were treated by *exercises* 102 cases, some of these patients also wearing a surgical boot without a valgus pad; by *wrenching*, 151, all wearing a valgus boot and iron after the operation.

**Occupation of the Patients with Flat-foot.** — Of the 1,078 patients treated for flat-foot in the Orthopædic Department during the years 1882-1893, 90 were at school, 82 were domestic servants (most of them cooks), 62 were errand boys, 61 shop-assistants, 44 housewives, 42 compositors, 37 porters (weight-carriers), 22 carpenters, 22 labourers, 16 waiters or waitresses, 15 bakers, 14 boxmakers, 13 bricklayers' labourers, 12 office-boys, 11 washerwomen, 11 dressmakers, 11 machinists, 10 bootmakers, 8 warehousemen, 8 barmen, 7 bookbinders, 7 ironers, 7 railway porters, 6 book-folders, 6 gardeners, 6 engineers, 5 dockers, 5 butchers, 5 blacksmiths, 5 clerks, 5 barmaids, 5 carmen, 5 electrotypers.

* The cases where the lateral curvature was the deformity for which the patient sought relief, and in some of which flat-foot was present, are not included, as these would stand in the books as cases of lateral curvature.

There were four of each of the following :—Hawkers, stevedores, pages, nurses, painters, tailors, milkmen, fishmongers, walking-stick-dressers, plumbers, metal-turners, farm labourers.

Three of each of the following:—Costers, laundrymen, cooks, umbrella-makers, cigar-makers, factory hands, travellers, barbers.

Two of each of the following:—Tea-packers, wheelwrights, salesmen, rulemakers, grooms, collectors, ropemakers, book-keepers, sailors, French-polishers, constables, lift-attendants, heelmakers, paper-stainers, navvies, wood-carvers, hatmakers, caretakers, carriers, insurance-collectors, farriers.

One of each of the following:—Letter-sorters, teachers, brace-makers, sweeps, tinners, ironfounders, bandsmen, woodcutters, leather-curriers, surgical-instrument-makers, lathe-makers, watermen, stopper-makers, sheep-drovers, cabmen, stampmakers, cellarmen, benchmen, dust-sorters, boiler-coverers, silk-warpers, lightermen, carriage-painters, keymakers, pattern-cutters, sugar-boilers, shipbuilders, harness-makers, button-holers, watchmakers, guards, bootlace-makers, pressers, postmen, dustmen, dairymaids, bottle-washers, glass-blowers, paper-moulders, gasfitters, envelope-folders, straw-plaiters, wool-twisters, machine-minders, bottlers, dyers, glass-silverers, upholsterers, sewermen, bagmakers, roller-makers, van-guards, soap-workers, billiard-markers, ornament-makers, founders, piano-makers, brushmakers, corn-chandlers, drilling-machine-makers.

## CHAPTER XIII.

## TALIPES CAVUS.

**Synonyms.** — Pes cavus; Pes excavatus; Pes arcuatus; Hollow claw-foot; Pied creux; Hohlfuss; Piede cavo; Piede plantare.

**Definition.**—This deformity is one in which the plantar arch is increased in depth by the approximation of the heads of the metatarsal bones to the posterior tuberosity of the os calcis.

**Varieties.**—Under the head of talipes cavus and the synonyms above given have been described several distinct pathological conditions having in common a deepening of the plantar arch. Thus, in talipes equinus, varus, and calcaneus, the plantar arch may be much increased in depth. But an increase in the depth of the arch may occur independently of these affections both as a congenital and as an acquired deformity. The following additional varieties may therefore be described: (1) Congenital talipes cavus; (2) acquired talipes cavus.

1. **Congenital Talipes Cavus—Pied Creux Congénital.**—An increase of the depth of the plantar arch with corresponding high instep is sometimes met with as a congenital affection, though seldom amounting to a deformity. It often appears to be hereditary, and is attributed to a primitive malformation of the ligaments and bones of the tarsus.* As a rule, no inconvenience is experienced, and walking is quite easy. At times, however, pain is felt in the instep or about the heel or heads of the metatarsal bones, especially after much exercise or long standing, but it is probable that this pain and discomfort is not so much dependent upon the increase in the arch of the foot as it is upon the tendency of the arch to give way as the result of the long standing

* Rédard, 'Traité de Chirurgie Orthopédique,' p. 839.

on the feet; *i.e.*, the pains complained of are those of commencing flat-foot.

In the way of *treatment*, a well-fitting boot with a surgical sole, and directions as to the proper use of the feet in walking, with such exercises as were mentioned under flat-foot, we have as a rule found to be successful in relieving the pain.

2. **Acquired Talipes Cavus.**—Several forms of acquired talipes cavus have been described of paralytic origin. The following may be mentioned:

*Hollow Claw-foot, the Griffe Pied Creux of Duchenne.*—This

FIG. 287.—PHOTOGRAPH OF TALIPES CAVUS WITH CLAWED TOES IN A BOY AGED TWELVE.

The foot could be dorsal flexed beyond a right angle with the leg, but there was some diminution of dorsal flexion. The interossei reacted to Faradism and galvanism. The other foot was similarly affected The deformity had come on gradually; there was no distinct history of its onset.

variety, which may occur without any equinus, is attributed by Duchenne to paralysis of the interosseous and lumbrical muscles and the short flexor and abductor muscles of the great toe. It has been met with uncomplicated, but more often associated with talipes equinus, with right-angled contraction of the tendo Achillis, or with paralytic talipes equino-varus (Fig. 287).

The plantar arch is much increased, and the toes are dorsal-flexed at the metatarso-phalangeal joint, and plantar-flexed at the first interphalangeal joint. The great toe usually presents a similar condition, being dorsal-flexed at the metatarso-phalangeal joint, and plantar-flexed at the interphalangeal joint. Not infrequently the great toe is affected alone, or is more affected than the other toes. The extensor tendons on the dorsum of the toes opposite the metatarso-phalangeal joints stand out prominently, and the plantar fascia is tense (Fig. 288).

In some of the cases that have come under our notice the muscles above mentioned have been found paralyzed, or perhaps we should say have been reported paralyzed by the Electrical

FIG. 288.—TALIPES CAVUS. (From a photograph of a patient in the Orthopædic Department of St. Bartholomew's Hospital, taken by Mr. Clindening.)

Department; in other cases there has been no paralysis discoverable. This point has been discussed under 'Equinus,' p. 263.

**Pathology.**—When uncomplicated by equinus, the deformity is the result chiefly of a plantar flexion of the tarsal bones at the transverse tarsal joint. On the paralytic view it is explained as follows: The interossei and lumbricales normally dorsal-flex the toes at the first interphalangeal joint, and at the same time plantar-flex the toes at the metatarso-phalangeal joint. When these muscles are paralyzed or weakened from any cause, their opponents, the long flexors and long extensors, being unopposed, throw the toes into the clawed position by plantar-flexing them

at the interphalangeal joint, and dorsal-flexing them at the metatarso-phalangeal joint. The clawed condition of the great toe is explained in a similar manner. Thus it is assumed that the short flexor and abductors are paralyzed, and the long flexor and long extensor being unopposed by the short, draw the toe into the clawed position.

Mr. Golding-Bird* believes that the deformity is often due to paralysis of the peronei muscles; the adductors, then acting unduly, approximate the balls of the toes to the heel, and, by taking the strain of the tread off the plantar fascia, allow this quickly to contract, and render the cavus permanent. The clawing of the toes he attributes in these cases, not to paralysis of the interossei, but to the extensors trying to extend the toes, which they cannot do fully, 'owing to the fact that the proximal ends of the first phalanges at the head of the metatarsal bones are kept down in the sole by the plantar fascial contraction. Hence the anterior ends of the first phalanges only get extended, and gradually the whole bone gets pulled on to the dorsal aspect of its respective metatarsal bone, producing the characteristic hammer-like toe. This also explains the prominence of the ball of the great toe towards the sole.'

At first, beyond an alteration in the normal relation of the bones and the adaptive shortening of the plantar fascia and the other soft tissues in the sole, there is no change in the bones; but in long-standing cases the articular surfaces become altered in direction and shape. The unopposed superior portions of the articular surfaces of the bones entering into the transverse tarsal joint lose their cartilages; whilst the lower portions undergo pressure-atrophy, so that their direction is altered, and a more or less distinct ridge is formed between the superior and inferior part of the articulation. These changes are perhaps most marked in the posterior bones, namely, the os calcis and astragalus. Moreover, from the long-continued clawed condition of the toes, the articular facets on the heads of the metatarsal bones are prolonged on the dorsal aspect of the bones, whilst towards the plantar surface the cartilage undergoes atrophy, and may disappear. On the heads of the first phalanges similar changes, but in a contrary direction, take place. In the meanwhile the liga-

* 'Guy's Hospital Reports,' 1883, vol. xli.

ments undergo shortening in adaptation to the altered relation of the joint surfaces. At the tarso-metatarsal joint of the great toe the articular surfaces for the sesamoid bones, in long-standing cases, also undergo alteration in position and shape.

**Treatment.**—The plantar fascia should be freely divided together with any tense band that may be felt in the sole, and if the extensor tendons still feel tense, they may also be divided where they are prominent on the dorsum of the toes. The foot should then be placed in plaster of Paris, with the arch and toes forced

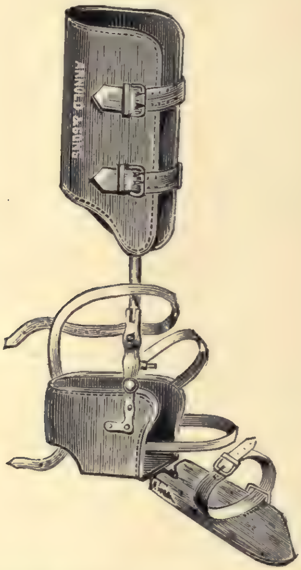



Fig. 289.—Modified Scarpa's Shoe with Moveable Sole-piece.

into the best possible position. The plaster may be changed in a fortnight, and the foot again put up for a like period after an attempt has been made to still further improve its appearance. If preferred, a shoe with a jointed sole-piece (Fig. 289), moved by a cog wheel, may be employed in place of the plaster, but unless it is very carefully looked after, pressure sores are apt to occur over the instep where the straps are applied. In severe cases division of the plantar fascia and contracted muscles, through an

open incision, has been practised. We are doubtful, however, when free subcutaneous division of the contracted structures in the sole and the division of the extensor and flexor tendons, fail, whether any further advantage could be gained by an open incision. In such inveterate cases the bones are at fault, and resist correction. In the way of after-treatment, a boot may be worn with a steel sole-plate, or, better, a gloved stocking may be employed, and the toes fixed to a steel plate (made to fit the boot) by means of elastic webbing—as shown in Fig. 289A. Manipulation of the toes and massage of the toes and foot should be assiduously practised for some months. The corns may be treated by shaving them down and applying the salicylate corn solvent.*

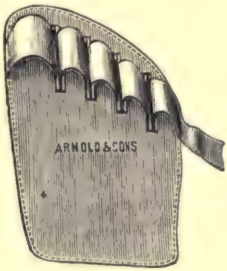



FIG. 289A.—STEEL SOLE PLATE PADDED AND PROVIDED WITH SLOTS THROUGH WHICH ELASTIC WEBBING PASSES AFTER EMBRACING THE TOES.

*The pes cavus* that may be found combined with *talipes varus and talipes valgus* is described under the heads of Varus and Valgus (p. 56).

*The pes cavus of talipes equinus*, the *pied creux équin*, has been described under Equinus (see p. 263).

*The pes cavus of talipes calcaneus*, the *pied creux talus*, has already been described with Talipes Calcaneus (p. 363). Under that head is also mentioned the cavus which is artificially produced in the foot of the Chinese female child.

* Acid. Salicylic. ʒss., Collodion ℥ss., Ext. Cannab. Indicæ gr. x.

## CHAPTER XIV.

# HALLUX VALGUS, VARUS AND DOLORUS.

## HALLUX VALGUS.

**Synonyms.**—Bunion; Valgus du gros orteil; Oignon; Clinodactylie du gros orteil; Déviation en dehors du gros orteil; Contrattura di abduzione dell' alluce.

FIG. 290.—DOUBLE HALLUX VALGUS. (From a patient attending the Orthopædic Department, St. Bartholomew's Hospital, photographed by Mr. Griffiths.)

**Definition.**—Hallux valgus is the term applied to a partial outward dislocation or displacement of the great toe at the tarsometatarsal joint.

### Etiology of Hallux Valgus.

Many theories have been advanced to account for hallux valgus. They may be considered under the heads of mechanical, ligamentous, muscular and arthritic causes.

1. **Mechanical Causes.**—The displacement of the great toe is undoubtedly, in our opinion, in the greater number of cases, due to the wearing of boots with median-pointed toes. This is the view taken by Hoffa,* and insisted upon by Ellis.† Bradford and Lovett‡ consider the deformity is entirely the result of improperly-shaped boots, and affirm that bare-footed people never suffer from it. On the other hand, Rédard regards the boot as only an occasional cause; for he says, How can we explain hallux valgus in patients who have never worn boots, or, at least, boots which never trouble them? Mr. Anderson§ also, although he admits that the majority of cases are undoubtedly provoked by ill-shaped boots, considers it 'very probable that some, and especially those of an aggravated type,' are 'dependent essentially upon an irregularity of development, and unconnected with any vice in the foot-covering. It is, at least, certain that some examples of extreme deformity are confined to one foot, the opposite member being of normal shape, a fact that strongly negatives the boot theory; and there are also bilateral cases in which the form of the distortion and the history given by the patients and friends, make it equally difficult to accept the common explanation.' Further, there are patients who insist that the toe went wrong by itself, and had nothing to do with the boot. We are quite ready to admit that there may be other causes, such as osteo-arthritis, gout, and possibly some developmental defect, as contended by Mr. Anderson; but we are equally convinced, as we before stated, that in by far the greater number of cases boots are the cause. We have frequently had patients declare that the boot had nothing to do with their trouble; that they had always worn good boots; while on inspection of the boots we have found them of the ordinary ill-shaped pattern of

* Hoffa, 'Lehrbuch der orthopaedischen Chirurgie,' 1891.
† Ellis, 'The Human Foot.' ‡ Bradford and Lovett, p. 753.
§ *Lancet*, vol. ii., 1891.

women's boots sold by low-class tradesmen, and on further inquiry have found that the patient had always worn them of the same shape. Indeed, we are doubtful if cheap scientifically-shaped boots for women are to be obtained. The deformity is only slowly produced through a series of years, and it is probably not till some accidental rubbing or other slight injury causes the bursa, which has been gradually forming, to become inflamed, or the overlying corn painful, that patients' attention is called to it; hence the persistence with which they declare their trouble had nothing to do with boots. It is no uncommon thing for patients attending the Orthopædic Department to take umbrage even at the suggestion that they have worn ill-shaped boots; and even on our pointing out the defect, it is difficult to convince them that the faulty shape is not all that is desirable.

2. **Ligamentous Causes.**—Some authorities regard the deformity as due to contraction of the external lateral ligament, or to the relaxation of the internal lateral ligament. No doubt the internal lateral ligament is stretched, and the external contracted and shortened; but this condition of the ligaments we regard as the result rather than the cause of the deformity.

3. **Muscular Causes.**—By some, as Nélaton, the deformity is attributed to contraction of the extensor proprius hallucis; by others, as Duchenne, to paralysis of the abductor muscles; whilst Dubrueil, again, regards it as the result of the adductors being stronger than the abductors. The adductors are contracted, but this contraction is surely due to passive shortening, the result of the approximation of their attachments, caused by the displacement of the phalanx. As to the alleged paralysis of the abductors, we have never been able to convince ourselves by electrical tests that any existed. We are not referring now to cases of infantile paralysis. It seems to us that Duchenne must have had this class of case in his mind.

4. **Arthritic Causes.**—A valgus position of the toe is common in osteo-arthritis; this condition, therefore, as well as chronic rheumatism and gout, must be regarded as a cause of the deformity. In osteo-arthritis of this joint the toe is nearly always displaced outwards, occasionally downwards, rarely upwards, never, as far as we know, inwards. Mr. Anderson regards the direction of the displacement as depending upon the position of the osteophytes

formed around the joint. Our own view is that it depends upon the direction given to the toe by the faulty boot. Hoffa believes that the deformity is never the result of chronic rheumatism, gout, or arthritis, but is itself the determining cause of these affections falling upon the toe.

### Pathological Anatomy of Hallux Valgus.

The first phalanx is more or less displaced, according to the severity of the deformity, on to the outer surface of the head of the metatarsal bone. It is in a position of partial dislocation, or subluxation, as it was formerly called. In severe cases the cartilaginous surface is prolonged on the outer surface of the head of the metatarsal bone; whilst the cartilage covering the unopposed portion of the head and inner surface is thinned, but may be eroded or have completely disappeared.

In *arthritic cases* the head of the metatarsal bone and the base of the first phalanx are enlarged on their inner aspect, whilst their outer parts have undergone more or less absorption. In gouty cases, deposits of urate of soda have been found in the cartilage.

The internal lateral ligament is elongated and often thickened, at times thinned, or even perforated;* the external lateral ligament is shortened. The flexor tendon and the sesamoid bones are displaced outwards from their grooves on the head of the metatarsal bone, and the grooves for the sesamoid bones become oblique,† thus maintaining or increasing the adduction. The adductors are usually contracted, the abductors stretched. We have not found either of them giving any evidence of paralysis. Over the prominent head of the metatarsal bone on the dorsal and lateral aspect of the toe, a bursa, which is sometimes multilocular, is developed, and is apt to become inflamed from the pressure of the boot, when it is commonly known as a bunion. Sometimes the inflammation may run into suppuration, and the abscess may open externally, or into the joint, or in both directions. Suppuration and destruction of the joint will then generally, though not invariably, ensue. In the skin over the

* Rédard, 'Traité Pratique de Chir. Orthop.,' p. 850.
† Hoffa, 'Lehrbuch der orthop. Chir.,' 1891, p. 714.

bunion a callosity or painful corn may form. A corn is also not uncommon in the skin of the plantar surface of the joint. In arthritic cases osteophytes are formed around the joint, giving rise to much enlargement and deformity, whilst the cartilage covering the head of the metatarsal bone and base of the first phalanx may become fibrous, or may disappear, as in osteo-arthritis of other joints, and the articular layer of bone become eburnated and porcellaneous.

### Signs and Symptoms of Hallux Valgus.

Some amount of displacement outwards of the great toe at the tarso-metatarsal joint is exceedingly common, especially in women. Such slight degrees of the deformity, however, as a rule,


Fig. 291.—Hallux Valgus of Right Foot and Hallux Varus of Left. (From casts in the Museum of St. Bartholomew's Hospital.)

give rise to no inconvenience, or to so little that they seldom come under the notice of the surgeon. The deformity is frequently associated with flat-foot, and it has been for this affection rather than for the hallux valgus that the greater number of slight cases have come before us. These mild degrees only cause trouble, as a rule, when from the rubbing or pressure of the boot a corn or bunion is formed and becomes inflamed. The deviation of the toe from the normal straight line may vary from

a few degrees to almost a right angle with the metatarsal bone. When much displaced, the great toe usually overrides the second toe, which is then frequently in the contracted condition known as hammer toe. At times the great toe is depressed below the second toe. In the latter case, which is said by Hoffa, but contrary to our experience, to be the more common, the condition known as ingrowing toe-nail is not infrequent.

The toe can be readily placed in the earlier stages, by slight traction, in a straight line with the foot, but in the more severe it becomes fixed by ligamentous contraction, and can be drawn

FIG. 292.—HALLUX VALGUS. (From casts in St. Bartholomew's Hospital Museum, taken from the feet of a patient in the Orthopædic Department.)

but very slightly or not at all from its displaced position. In exceptional cases it is held rigidly immoveable, and in rare instances may become ankylosed.

Bony grating in arthritic cases is felt and heard on moving the toe. When a bursa has formed (bunion), a fluctuating swelling is found over the prominent head of the metatarsal bone, and when this inflames, a brawny red swelling with much œdema around ensues. Should the bursa communicate with the joint, and the

latter become inflamed and suppurate, there will be some sharp constitutional disturbance. We have seen such suppuration extend amongst the muscles of the foot, giving rise to abscesses and caries or necrosis of one or more of the metatarsal or tarsal bones. After an acute attack of bursitis has subsided, the bursa may be left for weeks or months in an indolent state, often discharging through a minute aperture in the skin over the centre of the bursa. A corn over the bursa and on the ball of the great toe, or a callosity of the skin over the bursa, is not infrequent (Fig. 293).

Fig. 293.—Photograph of Casts of the Feet of a Man who had Dislocation of the First Phalanx of each Great Toe, with the development of a Bursa over the Head of the Metatarsal Bones.

The second and third toes of the right foot, and the second, third and fourth of the left were dorsal-flexed at the metatarso-phalangeal joint, and plantar-flexed at the first interphalangeal joint. The patient was admitted into St. Bartholomew's Hospital, and the heads of the metatarsal bones of the great toes were excised. Casts of the feet of the same patient after the operation are contained in the Hospital Museum, No. 58 B.

The deformity is more common in women than in men, in consequence, in our opinion, of the boots of women generally having a more pointed toe. In nearly all the applicants for the nursing appointments examined during the last five years at St. Bartholomew's, amounting to many hundreds of young ladies, hallux valgus

to some extent was present. Mr. Anderson and Dr. Robinson found that in the Mile End Infirmary hallux valgus was present in 10 per cent. of the inmates in the female wards, in 3 per cent. in the male. The deformity is one of adult life. Mr. Anderson only found it three times, and then in very slight degree, in 800 children under sixteen. In the Orthopædic Department we have seldom met with it under twenty.

In nearly all the cases seen in the Orthopædic Department, the deformity has been present in both feet, though in unequal degrees. Hoffa found that, out of 27 cases, it occurred 20 times on either the right or the left side, 7 times in both. Flat-foot was generally present in his cases—we think we may say it has almost invariably been so in ours when the hallux valgus was well marked.

### Treatment of Hallux Valgus.

The indications are to straighten the toe and to prevent redisplacement. The methods of carrying out the indications will be considered under the heads of manipulative, mechanical, and operative treatment.

For slight cases, manipulation, the wearing of a gloved stocking in combination with one of the simple mechanical contrivances described under that head, and a properly shaped boot, have been found by us effectual. For severer cases we have excised the head of the metatarsal bone, and can speak in the highest terms both of the immediate and the remote results of the operation.

Frequently the surgeon is consulted for inflammatory trouble in the bursa over the end of the displaced phalanx. The methods of dealing with this are discussed under the treatment of the bunion, p. 510.

1. **Manipulative Treatment** is only of service in slight cases, and is useless unless a proper boot is worn whilst it is being carried out. It is best to combine it with some form of simple mechanical appliance. The toe should be grasped with one hand, whilst the foot is steadied with the other. It should be then gently but forcibly abducted, and thus held for some ten minutes at a time, so as to put the external lateral ligament, and other contracted tissues on the outer side of the toe, on the stretch. Massage of the abductor muscles, and passive movements of the joint, may advantageously

be practised at the same time. The patient, with his shoes and stockings off, should be taught to abduct his toe. Thus, with the foot flat on the ground, the great toe should be drawn as far as it will go from the other toes, and the patient then pressing it firmly to the ground, should rise to tip-toe, keeping the great toe fixed whilst he endeavours to rotate the other toes with the remainder of the foot inwards at the medio-tarsal joint. This exercise should be practised night and morning for ten minutes at a time.

2. **Mechanical Treatment** may be considered under the heads of (*a*) strapping and bandages, (*b*) stockings, (*c*) splints and cog-wheel apparatus, and (*d*) boots.

(*a*) *Strapping and Bandages.*—A piece of strapping six to eight inches long, and half an inch to an inch wide, is split longitudinally at one end with the scissors for about two inches. Each half-width is then fixed round the toe, the toe drawn away from the other toes, and the strapping fixed to the side of the foot, thus holding the toe in the rectified position. It is only of service in slight cases. There are various other modifications of applying the strapping. A method sometimes found useful is to fix, with a strip of strapping, a wedge-shaped pad of lint between the great and second toe, thus keeping them apart. None of these methods are, of course, of any service unless a properly-shaped boot is worn, and this applies equally to the other methods to be described.

Noble Smith fastens a bandage round the toe, and draws the toe away from its fellow by passing a thread attached to the bandage through the toe of the boot. Beely, to prevent the patient having wet feet when using this appliance, fixes the thread inside the boot.

(*b*) *Stockings.*—A stocking having a separate stall for the great toe should be worn. Such a stocking not only in itself tends to correct the deformity, but permits of the wearing of a simple mechanical contrivance within the boot, or of the use of a wedge in the sole of the boot between the great and second toe, or of the steel sole-plate. Ellis advises that the sock or stocking should be straight along the inner edge, in place of the ordinary median-pointed shape.

(*c*) *Splints and Cog-wheel Apparatus.*—Numerous splints have

been invented for the treatment of the deformity. They are only of service in the slight or more moderate grades. For advanced cases some operative procedure is necessary. The splint we have found of most service is Krohne's lever-splint (Fig. 294).* It consists of a lever-spring made of metal about half an inch wide covered with leather. It reaches from the middle of the great toe to the posterior end of the arch of the foot. The fulcrum is kept in position by a well-padded rectangular plate jointed to the lever; the toe is secured to the distal end of the lever by a soft leather circlet; at the other end of the lever an elastic band, about an inch wide, is fixed at right angles, and is carried in a

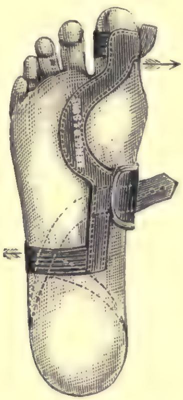


FIG. 294.—KROHNE'S LEVER FOR HALLUX VALGUS.

figure-of-eight round the foot and ankle, and attached to a button on the rectangular plate. The lever is so shaped that pressure on the great toe joint is avoided, and it can be worn in a well-fitting broad-toed boot. The apparatus is very useful in the slighter degrees of the deformity. It is in our opinion the best form of apparatus in use, in that it fits more accurately, takes up less room, and consequently does not necessitate the wearing of such large and ugly boots as does the ordinary bunion-spring to be next described.

Another splint in common use is Bigg's bunion-spring (Fig. 295). It consists of a spring which is fixed, as shown in the illus-

* *British Medical Journal*, vol. i., 1887, p. 943.

tration, to the side of the foot by suitable straps. Opposite the bunion, over the tarso-metatarsal articulation, it is hollowed out so as to avoid pressure at this spot. To the front of the spring a soft leather toe-cap is fixed. The toe having been placed in the cap, the splint is adjusted to the side of the foot, when the spring draws the displaced toe away from the smaller toes. It can either be worn well padded within the stocking, or, better, outside a gloved stocking. It necessitates, however, a roomy boot, and is therefore perhaps more generally reserved for night-wear.

Some surgeons employ a shoe, to which is fixed a lever, moved by a cogwheel or cogwheels, so arranged as to evert the great toe, and if necessary flex or extend it at the same time.

Another device is a wedge fixed to a movable sole-plate, the wedge, which is softly padded, having the apex towards the cleft of the toes. Broca, in place of the wedge, fixes a metallic spring,

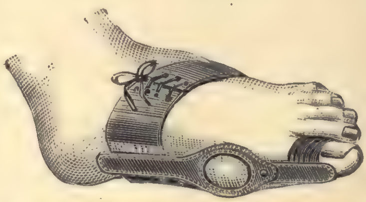


FIG. 295.—BIGG'S BUNION SPRING FOR TREATMENT OF HALLUX VALGUS.

formed of two stems in the shape of a V, to the sole-plate. The spring, like the wedge, when *in situ*, is situated between the great and second toes, forcing them apart. Both of these contrivances necessitate the gloved stocking.

(*d*) *Boots*.—The essential in the boot is that the inner edge should be straight or slightly concave, so as to allow room for the great toe to resume its normal position. The other features of a good boot have already been mentioned elsewhere (p. 453). The boot with the toe-post described under flat-foot (p. 454), and again shown in Fig. 296 will be found very useful for slight cases. When a bunion has already formed, pressure must be removed from it by having the boot at this spot hollowed out, or a piece may be cut out of the boot, and a hollowed-out piece of leather sewn over the hole which would be otherwise left.

3. **Operative Treatment.**—For all severe cases some form of operation is necessary if the toe is to be restored to the straight position. Many patients, however, when fitted with a boot so made that no pressure is exerted on the prominent metatarso-phalangeal joint and superimposed bunion, suffer so little inconvenience that they consider it hardly worth their while to have the deformity removed.

The operations that may be undertaken are (1) forcible rectification, (2) excision of the head of the metatarsal bone, (3) excision of a wedge from the head of the metatarsal bone, (4) osteotomy of the metatarsal bone, (5) removal of the base of the first phalanx, and (6) amputation of the toe.


FIG. 296.—TOE-POST IN THE BOOT FOR TREATMENT OF HALLUX VALGUS. (Holden Brothers.)

When, notwithstanding the removal of pressure by a properly-shaped boot, pain and inconvenience continue, and walking is rendered intolerable, one or other of the above-mentioned operations should certainly be advised. We have almost invariably practised excision of the head of the metatarsal bone, and we speak from personal experience in the highest terms of this little operation both in regard to its immediate and remote results. It is the one which, when mechanical means have failed or are unsuitable, we invariably advise.

1. *Forcible Rectification.*—Forcible rectification consists in wrenching the toe into as good a position as possible, with the patient under an anæsthetic. It may be advantageously combined, in some cases, with the subcutaneous division of the external lateral

ligament. After the wrenching, the toe may be secured in the restored position, either by means of plaster of Paris, or by fixing it to a simple splint of leather, gutta-percha, or poroplastic felt. A retentive apparatus of some kind should be subsequently worn at night, or, better, both night and day, to prevent a relapse. This method is well spoken of by some surgeons. We have not practised it ourselves, as it seemed to us hardly sufficient for the severe cases calling for operation met with in the out-patient rooms, and the milder degrees of the deformity occurring in better-class practice, we have found, as a rule, can be dealt with efficiently by less severe measures. However, in suitable cases it would appear to be a satisfactory procedure.

2. *Excision of the Head of the Metatarsal Bone.*—When done with modern surgical precautions, this operation is very successful, and, as a rule, leaves the patient with a fairly movable joint.

The skin should be carefully rendered aseptic, and the bursa, if inflamed, allowed to quiet down before the operation. The patient having been placed under an anæsthetic, and an Esmarch's bandage applied, an incision in the direction of the long axis of the foot should be made over the dorsal and inner aspect of the great toe, parallel and just external to the long extensor tendon. The incision should extend down to the bones. The joint having been opened, the head of the bone should be cleared with a few touches of the knife, and removed by a small keyhole saw or bone-scissors. The bursa should be next completely dissected away, and the wound swabbed out with antiseptic lotion, accurately closed by suture, and dressed with antiseptic gauze and wool. The toe and foot should be then placed in plaster of Paris, or, if preferred, on a moulded splint, before the Esmarch's bandage is removed. On the excision of the head of the bone, the toe can easily be placed in the normal straight line with the metatarsal bone, and on the healing of the wound, except that the toe is shortened, little evidence remains of an operation having been performed. We have usually allowed the dressing to remain on for three weeks to a month, and on its removal have found the wound soundly healed. Passive movements may advantageously be employed for some weeks or months to ensure mobility of the toe. The wound becomes filled with an aseptic blood-clot, and fibrous union between the car-

tilage-covered base of the first phalanx and the end of the metatarsal bone ensues. A properly-shaped boot and a gloved stocking should of course be subsequently worn. Mr. Anderson* considers the operation a very severe procedure, and one that is rarely justifiable. Our experience has led us to a diametrically opposite opinion.

3. *Excision of a Wedge-shaped Piece from the Inner Side of the Head of the Metatarsal Bone.*—Riedel prefers this operation to the removal of the whole head of the bone, since he found that, in some cases in which the latter operation was done, the heads of the four outer metatarsal bones, having to bear the weight, sank to the ground, whilst the toes were dislocated dorsally. Although we have performed the operation many times we have not met with such a mishap.

4. *Osteotomy of the Metatarsal Bone.*—Mr. A. E. Barker, for a severe case† of hallux valgus, removed a wedge-shaped piece of bone from the inner side of the neck of the metatarsal bone, so allowing the head of the bone, the joint, and the phalanges to be brought into the normal line. It is questionable, however, whether it is necessary to remove a wedge-shaped segment. As a rule, we think, a linear osteotomy of the neck of the bone will be sufficient. Some years ago one of us helped a colleague, Mr. Willett, to do such an operation. He partially cut through the bone by means of an Archimedean drill, and fractured the remaining portion. The toe was then readily brought into a good position, and thus fixed on a splint. The operation was in every way successful. From the experience thus gained, we should in future divide the bone with the ordinary osteotome through a small incision on the inner side.

5. *Removal of the Base of the First Phalanx* is preferred by Mr. Davies-Colley to removal of the head of the metatarsal bone, in that he thinks it is less likely to interfere with the tripod strength of the foot. The operation is done through a similar incision to that for removal of the head of the metatarsal bone. The objection to the operation is that it does not get rid of the enlarged and ill-shaped head of the metatarsal bone.

6. *Amputation of the Toe.*—Amputation of the great toe at the

* Anderson, 'Contraction of Fingers and Toes,' *Lancet*, vol. ii., 1891, p. 281.
† Barker, *Lancet*, vol. i., 1884, p. 655.

tarso-metatarsal joint may be required in exceptional cases, where suppuration of the joint has occurred, attended with extension of the inflammation to the metatarsal bone and surrounding soft tissues.

*Treatment of Inflamed Bunion.*—When acutely inflamed, the foot should be elevated and cold lotions applied, which should be changed for hot boracic poultices should suppuration threaten. If pus forms, it should be let out by a free incision. In the chronically inflamed condition all pressure should be removed, the patient wearing a roomy slipper or gout-boot, or a boot hollowed out at the spot corresponding to the bunion. Stimulating ointments, the oleate of mercury, or strapping with Scott's dressing, or ammoniacum and mercury plaster, may be tried, or, these failing, the bunion dissected out.

## HALLUX VARUS.

**Synonyms.**—Pigeon toe ; Déviation du gros orteil en dedans.

**Definition.**—Hallux varus is a condition in which the big toe is abducted, or unnaturally drawn away from the other toes.

**Etiology.**—We have in a few instances met with this condition of the great toe as a congenital affection, unassociated with any other deformity of the foot. At times it occurs in connection with congenital varus, and occasionally with severe genu valgum.

Mr. Reeves describes it as sometimes due to contraction of the abductor hallucis, and as 'a premonitory symptom of a form of paralysis which leads to spastic or rigid contraction and retraction, producing first varus and then equinus.'* We have no experience of the condition to which he refers. Hoffa† has seen hallux varus in conjunction with talipes valgus accompanying congenital defect of the fibula.

**Morbid Anatomy.**—We are not aware that any observations have been made on the anatomy of the deformity, and we have had no opportunities of making any ourselves. It would appear from clinical investigation that the abductor hallucis is sometimes contracted, and the internal lateral ligament shortened. In other instances that have come under our notice, however, there was

* Reeves' 'Practical Orthopædics,' 1885, p. 317.

† Hoffa, *op. cit.*, p. 719.

no evidence of either condition being present, since the great toe could be placed quite readily in contact with the other toes, though it resumed the faulty position when allowed to go free. In these cases, it seemed to us, there was some congenital alteration in the shape of the articular surface of the bones, possibly some slight deficiency on the inner side of the head of the metatarsal bone or base of the first phalanx, so that the natural direction of the toe was forwards and inwards, instead of directly forwards; but this is mere speculation, we have had no opportunity of verifying our surmise.

**Signs.**—Hallux varus is much less common than hallux valgus. The cases we have met with have always been in children, generally in infants. In infantile cases the deformity has sometimes been associated with congenital varus, the inward deviation of the great toe then appearing to be merely a somewhat exaggerated condition of the slight inward deviation commonly present in that deformity. In other cases, with the exception of the great toe projecting inwards, there was no other apparent deformity of the foot. In the most severe forms that we have seen, the inwardly projecting great toe formed an angle of about forty-five degrees with the inner side of the foot. In the majority of cases it was much less. Mr. Anderson,* in his lectures, relates and figures a case in which the toe projected inwards almost at a right angle with the metatarsal bone. The toe was somewhat imperfectly developed, and the smaller toes were distinctly hypertrophied, but otherwise well formed. The toe in this condition can usually be freely moved by the patient, but in severe cases, as, for instance, that related by Mr. Anderson, the abnormal direction prevents a boot being worn, and the function of the tendons is so interfered with as to render the foot or toe practically useless.

**Treatment.**—In slight cases, manipulation of the toe, that is, holding it in position whilst the infant is being nursed, aided by strapping and a bandage, will usually suffice. In some cases we have found a plaster of Paris bandage of advantage, in that continuous pressure is thus kept up, and the child is unable to kick it off. A thick layer of cotton-wool beneath the plaster should always be employed. In severe cases, a simple splint or sandal

* Anderson, 'Contraction of Fingers and Toes,' *Lancet*, vol. ii., 1891.

applied to the inner side of the foot, so as to force the toe into place, is used by some surgeons; but plaster of Paris can be made to serve the same purpose, and is equally good. In intractable cases, subcutaneous division of the internal lateral ligament, and the application of a plaster bandage, has had the desired effect. Tenotomy of the abductor hallucis has been recommended, and we see no objection to this operation if the internal lateral ligament is divided at the same time.

## HALLUX DOLOROSUS.

**Synonyms.**—Hallux flexus; Hallux rigidus; Painful great toe.

**Definition.**—The term hallux dolorosus is here applied to a condition of the great toe attended with pain in the metatarso-phalangeal joint on movement, but unaccompanied by signs of inflammation. This condition, which was first brought prominently before the profession by Mr. Davies-Colley, is called by him hallux flexus, by others hallux rigidus, in that the great toe is frequently flexed, and held more or less rigidly in this position. We prefer the term dolorosus, however, as in many cases we have met with, beyond the pain on movement, there has been little or no flexion, and practically no rigidity.

**Etiology.**—The painful condition of the toe has been attributed to the wearing of short or improperly-shaped boots, and to flat-foot. In our experience, it is a frequent accompaniment of flat-foot; but we have always found, on inquiry in these cases, that the patient has worn boots that were too short for him. We have come to the conclusion that, as regards the causation, in the majority of cases Mr. Cotterell is right in his surmise, that it is to be attributed to the combination of flat-foot, or incipient flat-foot, with too short boots. As the arch sinks, the foot, especially its inner border, becomes longer. If this lengthening is interfered with, by the boot being of insufficient length, stress is thrown chiefly on the proximal joint of the great toe, and the painful condition here described is the result. That this is a correct view of the case, we venture to think the result of our treatment tends to confirm. We have found that measures directed to the cure of the flat-foot, or incipient flat-foot, together with the use of a boot allowing ample room for the great toe, have invariably cured the

painful condition. Moreover, in conjunction with the painful toe, there has nearly always been the characteristic pain in other parts of the foot and ankle, so commonly present in incipient flat-foot. Mr. Anderson, however, believes that short boots and flat-foot have nothing whatever to do with the causation of the painful toe. He regards it as the result, like hammer toe, of 'irregular nutrition, by which the ligamentous fibres of the lateral ligaments undergo imperfect longitudinal development.'

**Anatomy of Hallux Dolorosus.**—Few opportunities of examining the condition of the toe occur. In a specimen obtained by Mr. Davies-Colley, the plantar fibres of the lateral ligament and the tendinous tissue connecting the sesamoid bones, which in the great toe replace the glenoid ligament of the lesser toes, appear to be contracted, and thus limit the extension of the toe. In the earlier stages, speaking from clinical experience, there has seemed to us to be neither flexion nor limitation of extension, and we have come to regard the limitation of extension, and later the position of marked flexion, which in some cases supervenes, as the result of adaptive or passive contraction of the ligamentous structures on the plantar aspect of the joint, and not as due to any primary developmental defect.

The *cause* of the pain has been a subject of much dispute. We attribute it to the stretching and spastic contraction of the long dorsal-flexor, brought about, as explained when dealing with the subject of pain in flat-foot (p. 429), by the sinking of the arch. The effect that too short a boot may have in helping to produce or aggravate the pain is there also discussed.

**Signs.**—This condition of the great toe is most frequently met with in growing lads; it is much less common in girls. The great toe may appear normal, or elongated, or occasionally slightly flexed, but rarely markedly flexed; in a few cases we have even found it hyper-extended. The metatarso-phalangeal joint may seem slightly enlarged, but often, on comparing the joint with that of the opposite side, the enlargement is found to be apparent rather than real. On flexing the toe, exquisite pain is caused, and a crackling sensation in the joint is generally elicited. Extending or hyper-extending the toe also causes pain, sometimes as severe as when flexing; but, as a rule, we have found that flexion causes most. At times the pain can be

produced by flexing the interphalangeal whilst the metatarso-phalangeal joint is held immovable. It then seems that the pain is caused by the movement of the tendon. The toe is generally more or less rigid; hence the term rigidus which is applied by some to the condition. The rigidity, however, appears to be due, at any rate in the earlier stages, to the voluntary effort of the patient, who holds the toe stiff on account of the pain that is caused by movement.

In conjunction with the pain in the great toe, we have invariably found some flat-foot, at times well marked, at other times incipient. In a few cases there has been no apparent sinking of the arch, but in addition to the pains about the foot and ankle, so characteristic of incipient flat-foot, there has been a history of an occupation necessitating excessive hours of standing. In some cases the toe has been more or less in the valgus position.

The condition under consideration must of course be distinguished from a painful state of the great toe due to inflammation, gout, rheumatism, or osteo-arthritis.

**Treatment.**—We have usually directed our treatment to the cure of the flat-foot, whether incipient or marked, leaving the toe, as far as local treatment is concerned, alone. Thus, we have ordered the exercises, boots, etc., described under the treatment of flat-foot, according to the degree of flat-foot that might be present. The tip-toe exercises, however, are not applicable to these cases, in that the pain and rigidity, when present, prevent the necessary movement. The other exercises can be done, and with advantage. The boot should be long, to allow plenty of room for the toe. Under this treatment the patients, we think we may say, have invariably got well. Some surgeons advise wrenching the great toe, and then fixing it in plaster; others, division of the ligaments, osteotomy of the neck of the metatarsal bone, or excision of the metatarso-phalangeal joint. We do not consider any of these methods are necessary; indeed, we have never resorted to any of them, except wrenching, and we cannot say that from this we obtained any marked benefit.

## CHAPTER XV.

### HAMMER-TOE.

**Synonyms.**—Orteil en marteau; Orteil en Z; Orteil en cou de cygne; Orteil en grippe; Hammerzehe.

**Definition.**—Hammer-toe is a condition in which the first phalanx is dorsal-flexed, and the second phalanx plantar-flexed. Mr. Anderson* defines the condition as one 'in which, in its complete form, there is a permanent flexion of not less than thirty degrees from the straight line at either or both of the interphalangeal joints without paralysis of muscles, unattended with any primary degenerative or inflammatory disease of the articular structures, and essentially confined in origin to the period of active growth.'

As thus defined, hammer-toe has to be distinguished from the hammer or claw-like conditions of the toes frequently met with in infantile paralysis, and from all contractions of the interphalangeal joints the result of inflammation. Mr. Anderson's definition would also exclude the minor degrees of the affection, but these are retained here.

#### Pathological Anatomy of Hammer-toe.

Several distinct pathological conditions of the toes were formerly classed together under the head of hammer-toe, such as the clawing of the toes, so common in some forms of infantile paralysis. These are described under talipes, etc., in different parts of the book.

The morbid anatomy of true hammer-toe as here defined has

* 'Lectures on the Contraction of the Fingers and Toes,' *Lancet*, 1891.

now been placed on a proper basis by the dissections of Messrs. Shattock, Anderson, Walsham, and others, and specimens illustrating the condition of the parts are preserved in the museums of St. Thomas's and St. Bartholomew's Hospitals, etc. From these specimens it is clearly shown that the deformity depends on a contracted and shortened condition of the plantar fibres of the lateral ligaments, and of the glenoid ligament or plate, which takes the place of a plantar ligament. The extensor and flexor tendons, though shortened, have not any material share in maintaining the bones in the deformed position. In a foot with a hammer-toe, amputated for an ulcer on the leg, Mr. Walsham found, on dissecting the toe, that the division of the flexor and

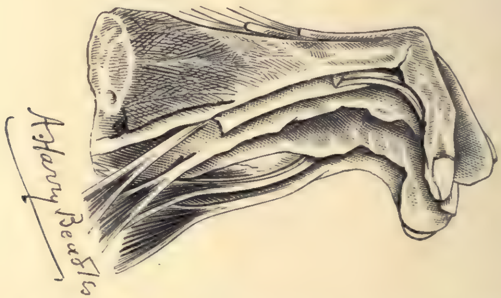


FIG. 297.—A HAMMER-TOE FROM A DISSECTION BY MR. WALSHAM, IN THE MUSEUM OF ST. BARTHOLOMEW'S HOSPITAL.

**The foot was amputated by him for other causes.**

extensor tendons did not allow of the correction of the deformity which still remained after all of the soft tissues, with the exception of the glenoid and the lateral ligaments, had been cut away. The specimen is now in the museum of St. Bartholomew's Hospital (Fig. 297). The interossei are also preserved in this foot, and were found to have a normal structure. The dissections prepared by Messrs. Shattock and Anderson, and at present in St. Thomas's Hospital Museum, demonstrate the same condition. This fact, that the deformity is due to contraction and shortening of the ligaments, has an important bearing on treatment.

The upper third or half of the articular surface of the head of the first phalanx is no longer in contact with the articular surface of the base of the second phalanx, and in long-standing cases the cartilage covering this part of the bone has been found thin and atrophied, and sometimes separated from the cartilage on the lower and plantar aspect of the head by a distinct groove. In some instances there is said to have been ankylosis between

FIG. 298.—PHOTOGRAPH OF A CAST OF A FOOT WITH HAMMER-TOE. (Fron patient in the Orthopædic Department, St. Bartholomew's Hospital.)

the first and the second phalanx. We have never met with this condition.

### Etiology of Hammer-toe.

Hammer-toe is frequently hereditary; occasionally it is congenital; more often, in our experience, it is an acquired deformity. It may therefore be considered under the heads of hereditary, congenital, and acquired hammer-toe.

**Hereditary Hammer-toe.** — Hammer-toe has long been considered by some authorities as an hereditary affection, and the history of the deformity in one or more members of the family can often be traced through several generations. We have met with such histories ourselves, and examples have been published by Mr. Adams,* Mr. Anderson,† M. Blum,‡ and others. A striking instance is related by Mr. Anderson as occurring in the practice of a colleague, in which the deformity was traced through four generations. Mr. Anderson affirms that an hereditary influence has been traced in at least a fourth of the examples that have come under his notice. We have made careful inquiries of patients who have presented themselves at the Orthopædic Department, and although we could cite many instances where hammer-toe has been traced through two or three generations, we have met with many more where we could obtain no history of it in other members of the family.

Such negative evidence, we admit, is not of much value, seeing the class from which the majority of patients attending the Orthopædic Department are drawn. But in a good number of the cases it was quite clear that the deformity did not exist in the father, mother, brothers, and sisters of the patient; in only a few cases could we depend upon the statement that it was not present in the grandparents.

Hammer-toe appears to be not infrequently associated with other deformities of a like nature, such as hammer-fingers, double-jointedness, etc., in the parents and grandparents. In one example, related by Mr. Anderson, five children out of eleven had hammer-toe; and there was also a history of 'double-jointedness in the fingers and thumb, extending through three generations, and an aunt on the male side was also the subject of hammer-finger.'

**Congenital Hammer-toe.**—Hammer-toe is said to be occasionally congenital; by some,§ indeed, it is looked upon as a con-

* Adams, Medical Society Transactions, March 19, 1888.

† Anderson, *Lancet*, vol. ii., 1891, p. 213.

‡ Blum, Bull. de la Soc. de Chir., 1883.

§ Wheeler, Trans. Roy. Acad. Med. in Ireland, vol. x., 1892. Swan, *ibid.* Mr. Swan says: 'I believe it is always congenital, although the inconvenience of the conformation does not arise till the foot has been used, and it may certainly be aggravated by ill-fitting boots.'

genital affection. For our own part, we have never met with it as such—that is, we have not known it to occur at birth. In a few instances we have seen it in infants under one year of age, but as a rule it has first shown itself about puberty. It may occur, however, at any time from birth up to twenty-one years of age. According to Mr. Anderson, it 'most frequently first attracts attention during the third quinquennial period,' and to this we are inclined on the whole to agree.

**Acquired Hammer-toe.**—Many theories have been advanced to account for acquired hammer-toe. They may be divided into the mechanical and the physiological.

The *mechanical theories* lay the deformity at the door of the shoemaker. By some writers too short shoes, by others median-pointed shoes are regarded as the root of the evil. Those who uphold the too-short boot view contend that the second toe, being normally longer than the great toe, is either pressed back by the short boot, or, being restricted by the boot in its forward growth, is forced to develop in the hammer-toe position. From habitually holding this position the ligaments become permanently contracted.

Mr. Ellis blames the median-pointed boot. The narrow-pointed boot forces the great toe towards the small toes, and thus compels the second toe to assume its hammer shape in order to make room for the other toes. He contends, moreover, that in countries where shoes are not worn hammer-toes are not found.

Mr. Anderson, on the other hand, expresses himself as equally confident that few, if any, of the examples of hammer-toe that have come within his own experience can be traced to any special defect in the form of the shoe. Only four of his patients confessed to having worn tight boots. 'In the rest neither history nor inspection indicated any fault of the kind, and the feet in the great majority were perfectly well formed in all other respects, and bore no marks of injurious compression.' He admits, however, that the 'use of shoes is, to some extent, and in a remote sense, a predisponent to this and to other analogous deformities. For it is certain that a rigid leather foot-covering, even when shaped according to the most scientific principles,

must necessarily interfere with the free action of the toes, and so with the processes of nutrition.' We have quoted Mr. Anderson's opinion at some length because our experience has been different from his. We have seen various other deformities of the toes, especially hallux valgus, and a crumpled-up condition of the little and two next toes, frequently associated with it, and on inspecting the boots that have been worn have found them about as bad and unscientific in shape as could possibly be. In a few instances the patients have themselves spontaneously traced the deformity to the wearing of specially tight or uncomfortable boots. One, of course, has to discount many of the statements received from the class of patients attending the out-patient room; but on the whole we have come to the conclusion that in many cases the deformity can be traced, not only, as Mr. Anderson says, in a remote sense to the use of shoes, but directly to ill-fitting and ill-formed ones. With regard to the statement that hammer-toe is not met with in bootless races, Mr. Anderson doubts if sufficiently extended observation has been made to verify it. He admits that he never met with it whilst he was resident for six years in Japan, nor was it observed by his friend, Surgeon-General Takaki; but, then, he says his observations were chiefly confined to the rising and boot-wearing generation of Japanese, and its absence in Japan is as much in favour of boots not producing the deformity as that bootless races are free from it. Moreover, seeing that the chief trouble from hammer-toe is due rather to the corn over the contracted toe, the result of the pressure against the boot, it is quite possible that hammer-toe may exist in bootless races; but giving rise, in consequence of the non-use of boots, to no inconvenience, it has not been brought under the notice of competent observers. On the whole, our own experience leads us to believe that it is certainly, as a rule, the result of badly-shaped and ill-fitting boots, even when it occurs with an hereditary history. Further, it should be remembered that in well-to-do families, where it has been traced for generations, the family bootmaker is often likewise an hereditary institution, and the badness of the boots made for the grandparents may have been handed down to the descendants. When it occurs in infants under one year of age,

as it is said by some authors at times to do, it is clear that it does not then depend upon the faults of the bootmaker. But in children of two or three years, however, we are not so sure that improperly-formed or too-short shoes may not have been a determining cause, notwithstanding the history of heredity, which can perhaps be traced, for the shoes worn by infants and young children are often improperly shaped, and in consequence of the rapid growth of the foot are frequently allowed to become too short. The slightest restriction to the growth of the toe, though it be but by a too-short woollen sock, may tend to cause the contraction.

Though adopting the *mechanical* theory, we can still conceive that heredity may have something to do with the development of the deformity. For inasmuch as every person who wears too-short or median-pointed boots does not develop hammer-toe, it may fairly be argued that there is some personal idiosyncrasy (plus the boot) at work. In some people the second toe is longer than the first, a possibly hereditary trait, and it may be in these that the restricting action of too short a boot comes more fully into play.

*The Physiological Theory.* — Various theories that may be called physiological, in contradistinction to mechanical, have been advanced to account for hammer-toe. Thus, Blum ascribes it to the contraction of the ligamentous capsule surrounding the joint, due to the irritation set up by the corn. Seeing, however, that the corn forms subsequently to the hammer-toe, we, with the generality of authors, look upon the corn as the result of the hammer-toe, not the hammer-toe as the result of the corn.

Boyer attributes it to contraction of the extensor tendon, Sanson to contraction of the flexor tendon. Both the extensor and the flexor tendons may be found contracted; but in our opinion the contraction is the result of passive shortening, rather than the active agent in the production of the hammer-toe. In the slighter grades of the affection there may be no contraction of the tendons whatever.

Some surgeons look upon it as the result of inflammation in the joints, others as due to paralysis of the interossei. The claw-toes, so common in some cases of pes cavus and talipes

equinus, are possibly in some instances due to paralysis of the interossei; but in true hammer-toe, as here described, in which but one toe, usually the second, is affected, the interossei are certainly not at fault. It is probable that those surgeons who speak of paralysis as a cause are referring to the clawed or hammer-toed condition above mentioned in the cavus and equinus forms of infantile paralysis.

Mr. Anderson considers that there is a 'physiological tendency to hammer-toe in a large number of people who never actually suffer any inconvenience from it, and it is in the exaggeration of this physiological tendency that we have to seek the pathology of surgical hammer-toe. The tendency ceases at adult life, because the ligamentous and bony structures of the articulation have then assumed their permanent condition.' The 'deformity must be regarded,' he says, 'as the result of insufficient longitudinal evolution of those fibres of the lateral ligament which have for their function the limitation of the movement of extension of the interphalangeal joints. This irregularity of development may be either inherited or accidental.'

Mr. Swan considers that the deformity is a partial reversion to a lower type of foot, and that the osseous elements of the grasping toes are developed out of all proportion to the soft structures. He argues that although the second toe in children with naked and undeformed feet may not be longer than the first,* that if the disarticulated bones of a hammer-toe are measured they are always found longer than those of the great toe.

## Signs of Hammer-toe.

In a well-marked case the first phalanx is extended, or, as better expressed, dorsal-flexed at the metatarso-phalangeal joint, whilst the second phalanx is plantar-flexed at the first interphalangeal joint. The third phalanx may remain in line with the second, or it may be plantar-flexed, or in some cases dorsal-flexed.

* Professor Flower examined the feet of many hundreds of children who had naked, and therefore undeformed, feet, and did not find a single instance of the second toe being longer than the first.

Over the prominent first interphalangeal joint the skin and subjacent cellular tissue is thickened, forming a callosity on which, from the rubbing of the boot, a corn is apt to form ; a second corn may also form over the end of the toe which is turned towards the ground, whilst a third is not uncommon on the sole beneath the head of the metatarsal bone. These corns, and especially that over the prominent angle formed by the meeting of the first and second phalanges, give rise to much pain and irritation, and are liable from time to time to become inflamed and suppurate. A bursa, moreover, may form beneath the corn, and in some cases may also become inflamed and suppurate. It is not very uncommon to find in the centre of the callosity, or corn, a small sinus leading into the subjacent bursa. The end of the toe becomes somewhat broadened and widened out, and from this appearance it is supposed that the term ' hammer-toe ' is derived. The great and the second toe override the end of the hammer-toe ; in some instances the great toe is dislocated outwards, giving rise to the deformity known as hallux valgus. As the result of pressure and dirt, some ulceration may occur around the nail of the hammer-toe, or the nail may be partially, as it is called, ingrown. On taking hold of the toe it can, in slight cases, be placed almost completely in the normal position ; but in more advanced cases practically no improvement can be produced. In advanced cases the extensor and flexor tendons are contracted—the extensor tendon often standing out distinctly on the dorsum of the toe, where it forms a distinct ridge. On the under surface of the toe the skin is contracted, so that in severe degrees the toe cannot be brought into line after operation without tearing or incising the skin. The slighter degrees of the affection do not, as a rule, in out-patient practice come under the care of the surgeon, and in severer cases it is the pain and crippling produced by the corn or bursa that usually leads the patient to seek for advice.

The toe usually affected is the second ; one foot, or both, may be the seat of the deformity ; both may be affected simultaneously, or one not till some months or years after the other. In a similar though slighter degree the little and fourth toes may be affected ; but what may be called the true hammer-toe condi tion is practically confined to the second toe. Occasionally the

second interphalangeal joint becomes deformed in a manner similar to the first.

### Treatment of Hammer-toe.

The indications for treatment in all cases are, where possible, (1) to straighten the toe; (2) to prevent its recontraction by appropriate after-treatment; and (3) in a few intractable cases to remove it by amputation. The measures that may be necessary for fulfilling these indications vary according to the degree of the deformity, and will be discussed in detail under the heads of (1) manipulation; (2) mechanical apparatus; and (3) operative measures.

Before passing to these, we will first give a brief outline of the treatment we have adopted for the various degrees of the deformity. Thus, in slight cases, and especially in the infant, we have often succeeded by manipulation combined with simply bandaging or strapping. In more severe degrees wrenching, with subsequent manipulation and a simple splint, has sufficed. In still more severe degrees, or where wrenching has failed to straighten the toe, the subcutaneous division of the glenoid and lateral ligaments has been practised. In very severe degrees the excision of the head of the first phalanx has proved an excellent operation, and though, perhaps, a little more severe measure than forcible rectification or subcutaneous division of the ligaments, may often be undertaken when time is the chief desideratum in preference to either. In certain cases some form of retentive apparatus is desirable to prevent recontraction, and should be worn either within a properly-shaped walking boot or at night-time. We have not practised tenotomy either of the flexor or extensor tendons, believing it to be an ineffectual measure; nor have we any experience of the open division of the ligaments. For only the most intractable degrees should amputation of the toe be performed.

1. **Manipulative Treatment.**—Manipulative treatment is only applicable as a means of cure in very slight cases, but is useful as an adjunct both to mechanical and operative measures. For slight degrees of the deformity in the infant the mother or nurse should be shown how to manipulate the toe. Taking the toe

between the first finger and thumb of the right hand, and steadying the foot with the left hand, the toe should be gently but forcibly straightened at the first interphalangeal joint as far as it will go without causing pain, by dorsal-flexing the two last phalanges, whilst the first phalanx is at the same time brought into line with the other toes. In this position it should be held for ten minutes or a quarter of an hour at a time, with the ligaments and tendons fully stretched. The flexor and extensor tendons should be gently massaged whilst the toe is thus held, and hyper-extension at the first interphalangeal joint, and hyper-flexion at the tarsophalangeal joint, occasionally practised. In the intervals between the manipulations the toe should be fixed in the corrected position either by the simple method of strapping, or by one of the splints or shoes mentioned below.

2. **Mechanical Treatment.**—Mechanical treatment alone, except in very slight cases, is not desirable. We do not say that the deformity, even when somewhat severe, cannot be cured by mechanical means, but the time and attention requisite are so great that in our opinion the mechanical treatment except in slight cases should only be employed as a supplement to the more effective and expeditious operative treatment. It may be considered under the following heads:

(1) *Strapping.*—This method is very useful for slight cases, especially in the infant. It should be combined, as a rule, with the manipulative method described above. Two strips about six inches long, and half an inch wide, are cut of ordinary diachylon, isinglass or other form of simple strapping plaster. One strip is carried under the great toe, with the adhesive surface towards the toe, through the cleft between the great and the second toe, over the prominent first phalanx of the second or hammer-toe, then through the cleft between the second and third toes, under the fourth and fifth, and back again over the fifth. The second strip is passed over the great toe through the cleft between the great and the second toe, under the second phalanx of the second or hammer-toe, then between the second and third, and over the third and the other toes. The first phalanx of the second or hammer-toe is thus pressed downwards, whilst the second and third phalanges are pressed upwards. The strapping should be changed frequently, as in the movements of

the child it is apt to become loose, and then of course ineffective. The mother or nurse can be readily taught how to apply it.

(2) *Bandaging.* — A domett bandage or piece of soft linen about half an inch wide is passed under the second phalanx of the hammer-toe, the two ends brought up between the cleft between the first and second and second and third toes respectively, crossed over its dorsum and then over the dorsum of the foot, and round the ankle in a figure-of-eight, and tied in front of the ankle. A second piece of equal width is better first applied over the dorsum of the hammer-toe, and then carried through the clefts between the hammer-toe and the first and third, and brought up over the sides of the foot and secured in like manner in front of the ankle.

The simple or double sling thus described, though only curative in slight cases, often gives great relief in the severer forms. The strapping is preferable to the bandage in infants and children, in that it is less liable to get loose.

(3) *Splints.*—Many forms of splint have been invented for the mechanical treatment of hammer-toe. They consist of gutta-percha, poroplastic felt, leather, wood, tin, iron, etc., moulded and shaped to the sole of the foot. Opposite the hammer-toe slots are cut so that the toe can be drawn down by means of a simple or elastic bandage to the splint. Under the last phalanx a pad may be placed to raise the end of the toe slightly, and thus increase the efficiency of the pressure of the bandage passing over the first phalanx and through the slots. Such splints can be readily made by the surgeon out of poroplastic felt or gutta-percha, or they can be obtained properly padded from the instrument-makers. Some surgeons, in place of the simple splints here described, employ a leather shoe, such as is shown in Fig. 299; but it seems to us to have little or no advantage over the splint, and entails expense. After the deformity has been corrected a T-splint for the toe should be used for six months or more to prevent a relapse. It can either be worn only at nights, or, better, within the walking-boot during the day as well. If a shoe or splint has been employed for correcting the deformity, this may be continued at night. When the hammer-toe is combined with hallux valgus, a splint should be adapted for the simultaneous correction of both deformities.

**3. Operative Treatment.**—In all severe cases some operative measure is necessary; in slighter cases it is often advisable, in that it shortens the duration of treatment. The chief operations that have been employed for the cure of hammer-toe may be considered in detail under the heads of (1) forcible rectification; (2) division of the ligaments; (3) excision of the joint; (4) amputation of the toe.

(1) *Forcible Correction.*—The patient having been placed under an anæsthetic, the surgeon, steadying the foot with the left hand, grasps the affected toe with the thumb and forefinger of his right hand, and forcibly straightens it. The toe should be so held that


FIG. 299.—LEATHER SHOE FOR THE TREATMENT OF HAMMER-TOE. (After Rédard.)

the thumb rests on the prominent angle formed by the first interphalangeal joint. The glenoid ligament and plantar fibres of the lateral ligaments are felt and heard to give way with a distinct snap or crack at the moment of yielding of the fibres. When this little operation is successful, the toe lies nearly straight, and with very gentle pressure can be kept in the straight position. It should then be fixed to one of the splints here described, or in some other approved apparatus. At times the contraction of the skin on the flexor aspect prevents the toes coming quite straight. We have succeeded in overcoming this difficulty by making a V-shaped incision through the skin on the plantar aspect.

(2) *Division of the Contracted Ligaments (Syndesmotomy).*—Divi-

sion of the ligaments may be done by the subcutaneous or open method.

*Subcutaneous Division of the Ligaments.*—Mr. Adams recommends subcutaneous division of the lateral ligaments. We prefer to divide the glenoid ligament or plate as well. It is believed by Mr. Adams that the lateral ligaments can be divided subcutaneously without opening the joint. It does not seem to us that it is possible to do so. Fortunately, it is a matter of little account, since no harm will come of opening the joint if strict antiseptic precautions are adopted.

The foot, and especially the skin between the toes, should be well washed, and all sodden epithelium got rid of previous to the operation. The skin over the site of puncture having been finally prepared in the way usual for an aseptic operation, and the patient placed under an anæsthetic, an assistant should hold the first and the third toes away from the second. The surgeon having defined the little tubercle on the base of the second phalanx, should enter the point of the tenotome immediately behind it, and, passing it deeply beneath the flexor tendons, carry it—held with the blade on the flat—across the plantar surface of the joint. The cutting edge of the tenotome should be next turned towards the joint, and the glenoid ligament divided by cutting into the joint. The contracted fibres of the lateral ligament on the side of the toe opposite to which the knife is entered may now be severed by depressing the handle of the knife, whilst those on the same side as the puncture may also be severed by still further depressing the handle as the tenotome is withdrawn. If the far lateral ligament does not seem to have been satisfactorily divided, a puncture may be made in a similar situation on the opposite side of the toe. On the division of the ligaments the toe can usually be placed in the straight position. In very severe cases, however, so much dislocation may have occurred that a complete rectification is impossible. Under these circumstances it is better to convert the puncture into a short incision, forcibly extrude the head of the first phalanx, and remove it with the bone forceps.

In some cases the contraction of the skin on the plantar surface prevents the toe being brought quite straight. We have then found a V-shaped incision, after the manner employed in freeing a

contraction of the skin of the finger, has been sufficient to overcome the difficulty.

At the completion of the tenotomy the puncture is closed with an iseptic gauze, secured by a strip of strapping, and the toe fixed in the straight position on some such splint as that described under mechanical treatment (p. 526). On this it is allowed to remain for a fortnight or so; subsequently the same splint, or one of those previously described, should be worn at nights for six months to prevent recontraction. If, notwithstanding the use of the night splint, any tendency is shown to recontraction, the T-splint should be worn in the boot also during the day. Properly-shaped boots are essential.

*Open Division of the Ligaments.*—A rough-and-ready method of dividing the ligaments is practised by Petersen, who divides them by an incision through the whole of the soft tissues on the plantar aspect down to the bone. Others divide the ligaments by an open incision, either on the dorsum or side of the toe. We see no advantage in these methods, and have not practised them. If the division of ligaments is sufficient to effect a cure, it can be accomplished as effectually by the subcutaneous as by the open method. The former, therefore, as involving a less extensive operation, should in our opinion be preferred.

(3) *Excision of the Joint.*—Complete or, better, as we think, partial excision of the joint between the first and second phalanx may in severe cases be necessary.

(A) *Partial Excision of the Joint.*—By partial excision we mean the removal of the head of the first phalanx, leaving the base of the second phalanx untouched. The advantage we claim for this method over the complete excision of the joint is that, by leaving the cartilage covering the base of the second phalanx intact, a movable joint is more likely to be obtained than when the cartilaginous end of the second phalanx is also removed and two exposed bony surfaces are left in contact. When the cartilage on the second phalanx is left intact, and the wound is completely closed and kept aseptic, an aseptic blood-clot forms, and fibrous union and a movable joint should be obtained.

*The Operation.*—The foot should be thoroughly cleaned, care being taken to remove all soft and sodden epithelium from

between the toes, and then placed in an antiseptic dressing till the time of the operation. If the bursa over the interphalangeal joint is in an unhealthy condition and suppurating, this should be rendered aseptic before the operation is undertaken. The corn may be treated after the operation.

The assistant holding the great and third toes apart, the surgeon should make an incision along the side of the toe over the first interphalangeal joint, taking care to avoid the digital artery and nerve. The bones being exposed, the lateral ligaments are divided, and the end of the first phalanx is protruded from the wound. The head of the bone is next removed with bone-scissors, and the wound closed accurately with sutures. The toe should then be placed in an antiseptic dressing, and the whole foot secured to a splint. The wound has been left in the original dressing for a week or ten days, and at the end of that time has usually been found healed. On the cicatrization of the wound, passive exercises of the toe are useful to ensure as much mobility as possible.

(B) *Complete Excision of the Joint.*—The steps of the operation are similar, except that after the head of the first phalanx has been removed, the base of the second is protruded through the skin incision and also excised.

The chief advantages of excision (partial or complete) of the joint are that there is practically no fear of a relapse, the after-treatment is reduced to a minimum, time is saved, and no expensive apparatus is required. There is a risk, however, of a stiff joint resulting.

(4) *Amputation of the Toe.*—Amputation should be reserved for severe cases. The toe should be removed in the ordinary way at the metatarso-phalangeal joint.

## CHAPTER XVI.

## DEFORMITY OF THE SMALL TOES.

### Lateral Deviation of the Small Toes.

Lateral deviation of the small toes is sometimes met with as the result of wearing improperly-shaped boots, occasionally as the result of osteo-arthritis, or of gouty or rheumatic affections of the joints. It may also occur in some forms of infantile paralysis, and is said by Bradford and Lovett at times to be due to unequal power in the antagonistic muscles. In rare instances it is met with as a congenital affection. By Mr. Anderson it is regarded as due to a cause similar to that to which he attributes hammer-toe and several like affections, namely, a physiological defect in the developmental process during active growth. He found a lateral deviation in twenty-five cases out of eight hundred children examined, of ages varying from five to fourteen.

**Signs.**—The toes may simply be deviated outwards or inwards, or they may overlap each other. In some instances they may be flexed as well as laterally deviated, so that the tips of the toes touch the ground. Corns, bursæ, or ulcerations are then frequent as the result of pressure or friction, and it is usually from the pain and inconvenience that these conditions cause that advice is sought. When the toes overlap, ingrowing of the nail in consequence of the pressure of one toe over the other is not infrequent. In two-thirds of the cases collected by Mr. Anderson, the fourth toe was alone affected, but the deviation was also common in the little toe. In our experience, although one toe has deviated perhaps more than the rest, all four have generally participated in the deflection. Deviation towards the tibial side is certainly more common than towards the fibular side.

Mr. Anderson found the proportion as six to one. The deviated toe may lie under or over its neighbour. The deformity is generally symmetrical, affecting both feet. At first, and in slight cases, the toe can be placed straight by gentle manipulation, but in long-standing and severe cases it becomes fixed in the deformed position by ligamentous contraction and alteration in the joints. We have seen it in connection with hallux varus, occasionally with hallux valgus, but frequently neither of these conditions of the great toe was present, nor were they so in any of Mr. Anderson's cases. It is at times associated with hammer-toe and like

FIG. 300.—PHOTOGRAPH OF THE CAST OF A FOOT THE TOES OF WHICH ARE UNNATURALLY UPTURNED. (No. 97, St. Bartholomew's Hospital Museum.)

From a woman aged twenty-four, who had had paralysis of the muscles of the calf for three years.

changes in the fingers. In arthritic cases the deviation is attended by enlargement of the affected joint, and other signs of osteoarthritis, gout or rheumatism.

**Treatment.**—In slight cases manipulation, a digitated stocking, and a properly-shaped boot will generally be found sufficient. In severer cases a steel sole-plate, with slots through which the toes can be confined in position by webbing or elastic straps, should be worn, either at night only, or, if the patient will submit to a sufficiently large boot to hold the sole-plate, during the day as well. In extreme cases resection of the joint, or even amputation,

when one toe is affected, may be called for. In the arthritic cases general treatment will have to be adopted.

### Flexion of the Small Toes.

Flexion of the small toes is met with in certain cases of infantile paralysis in which the extensor muscles are paralyzed. It is occasionally seen as a congenital affection, and we believe it may also be produced by short and improperly-shaped boots. Mr. Anderson looks upon a form of flexion of the small toes as due to developmental irregularity in the joints, with contraction of the lateral ligaments and glenoid plates. We have met with cases in which the flexion seemed to depend on contraction or shortening of the skin rather than on any of the deeper structures. We have also seen cases where the flexion was accompanied by a persistent eczematous condition of the skin.

### Deficiency of the Toes.

Congenital deficiency of one or more of the toes is not so very uncommon, and absence of all of the toes has been met with.* In the majority of cases, beyond the fact that one or two toes are missing, there is apparently no other deformity of the foot, but in such cases a metatarsal bone may be also absent or rudimentary. At times the deficiency of the toes is associated with other malformations of the foot, as deficiency of the metatarsus and tarsus corresponding with the absent toes. Thus, there is in the museum of St. Thomas's Hospital a foot of a girl aged ten in which the three inner toes are absent. The first and second metatarsal bones, the internal and middle cuneiform bones, and the scaphoid, are also absent; but the os calcis, the cuboid, and the external cuneiform bones can be detected. In such cases there is usually some displacement of the foot. In this instance the dorsum of the foot looked downwards, and the sole upwards, whilst the remaining bones of the foot had no connection with the tibia, which ended in a blunted internal malleolus, the patient walking on the end of the external

* Chance, 'Bodily Deformities.'

malleolus.* A more common condition in association with absence of the toes is absence of the fibula (Fig. 301). Indeed, so comparatively common is a deficiency of the two outer toes, and of the fibula, that the condition may be almost looked upon as a

FIG. 301.—PHOTOGRAPH OF A CAST OF THE RIGHT FOOT AND LEG OF A BOY, IN WHICH THERE WAS CONGENITAL ABSENCE OF THE FIBULA AND TWO OUTER TOES, WITH PARTIAL FUSION OF THE SECOND AND THIRD TOES.

There was much eversion of the foot. The right leg was five inches shorter than the left.

recognised deformity. In these cases the foot is usually in the position of equino-valgus, and the tibia is bent in a forward curve about the junction of its middle and lower thirds. Examples have been described by Pearce Gould, Wagstaffe, Humphry,

* 'Pathological Society's Transactions,' vol. xxxvii., 1886, p. 555.

Gurlt, Adams, Braun, Rédard, Bilroth, Nélaton, Kirmisson, and others, Braun alone having collected twenty-seven. Nélaton,* who has called especial attention to this deformity, points out that there is nearly always a linear cicatrix over the summit of the convexity of the curve in the tibia. He believes that the absence of the two outer toes and of the fibula is the result of intra-uterine pressure on the outer side of the leg, due to a too narrow amnion; that the curvature of the tibia with the outward deviation of the foot is the result of too small a space in the amnion to allow of the normal development of the leg in length; and that the cicatrix over the prominent curve in the tibia is the result of adhesion of the skin to the amnion at the point where the pressure was greatest. In the case reported by Mr. Pearce Gould† the great toe was normal, and there were two small webbed toes, probably the second and third, on its outer side. The foot was in a position of equino-valgus. The fibula was entirely absent, there being a deep wide groove between the outer border of the foot and the tibia at the spot where the external malleolus should be. The child was three years of age. The calf was fairly developed, and the peronei, tibialis anticus, and the extensors of the toes could be clearly traced.

In a case of absence of the two outer toes reported by Nélaton, the fibula was also absent, and the foot in an extreme condition of equino-valgus. In a case noticed by Kirmisson of absence of the fifth toe and of the fibula, there was a bony projection on the fourth toe, apparently a rudimentary fifth.

In Foerster's case‡ two toes were missing. There were no leg muscles, and the foot was small, contracted, and drawn back, whilst from the middle third of the thigh there was another leg, having a fibula and six toes—the inner toe being double. In a case related by Humphry,§ one toe was absent, the cuboid was also absent, and the toe representing the fourth and fifth articulated directly with the os calcis; the whole of the fibula was wanting.

In Ringhoffer's case, in which a similar deficiency of the fibula

* *Revue d'Orthopédie*, July, 1891.
† 'Pathological Society's Transactions,' vol. xxxii., 1881, p. 152.
‡ 'Die Missbildungen des Menchen'
§ Humphry on the Skeleton.

was present, the toes were found without phalanges, but with nails well formed; whilst in Faber's case the foot merely consisted of a mass of cartilage covered with skin.*

Absence of *part* of the fibula appears to be also not uncommon in connection with deficiency of the toes. Mr. Gould has collected several such cases in his paper in the 'Pathological Transactions.'† Thus, in Mr. Wagstaffe's‡ case, of absence of the second and fourth toe, the tarsal bones were fused together into a flat mass of bone, and the lower end of the fibula was absent. In another case of Mr. Wagstaffe's, of absence of the two outer toes, the lower part of the fibula alone was deficient, that bone being represented by only a small piece of bone in the situation of the head. In a case of deficiency of the three outer toes, reported by Schnelle, the lower part of the fibula was absent. In Meckel's case,§ in which the two outer toes were absent, the cuboid was also wanting, and the upper part of the fibula. In Billroth's case, of deficiency of the fifth toe, the lower part of the fibula was absent.

The foot in these cases of absence of the toes, with defects in the fibula, is generally in a position of valgus, but has been found in a state of equino-varus, varus, and extreme equinus. In a case recently under the care of Mr. Walsham, of absence of the little toe, the foot was in a position of extreme valgus; the external malleolus could not be felt, and was either defective or wanting. The internal malleolus was very prominent, and apparently hypertrophied. The division of the peronei and tendo Achillis had no effect in correcting the valgus, but the subsequent removal of a wedge of bone from the internal malleolus allowed the sole to be turned to the ground, and produced a useful foot.

### Hypertrophy of the Toes.

One or more of the toes, or all the toes, with a part or the whole of the foot, or even a part or the whole of the leg, may be the subject of congenital hypertrophy. The hypertrophy,

* Pearce Gould, 'Path. Soc. Trans.,' vol. xxxii., p. 155.
† *Ibid.*
‡ Wagstaffe, *Journal of Anatomy*, vol. vii., 1873.
§ Meyersohn, 'Virch. Archiv.,' vol. lxxvi.

when confined to a single toe, is perhaps most common in the hallux.* When two or more toes are affected, the toes on the inner side of the foot are most often involved. In specimen 3,502 in our museum, the three middle toes were hypertrophied, and in a case related by Mr. Davies-Colley† the two inner toes, and in one figured by Mr. Chance from a cast in the Hunterian Museum, the third and fourth. We know of no case in which the little toe was alone affected. The toe, or toes, in these cases may not only be enlarged, but may be also variously displaced or dislocated, pointing outwards or directly upwards or downwards at right angles to the rest of the foot,‡ and thus from their abnormal position, as well as from their great size, giving rise to much annoyance and inconvenience. The size the affected toe or toes may attain is at times immense. In the cast in the Hunterian Museum, before referred to,§ the affected toes are twenty times the size of the adjoining toes, and in the case related by Mr. Davies-Colley, the hypertrophied toes measured six inches and five inches in circumference respectively, as against two and three-eighths inches and one and three-quarters inches on the sound side. The hypertrophied toe or toes, in these congenital cases, may continue to preserve their abnormal relations in size to the other toes during development,‖ or after thus continuing or slowly increasing they may at length take on more active growth. In some remarkable cases, although the hypertrophy had always been noticeable, it was not till late in life that any active growth took place. Thus, in Mr. Eve's case,¶ the patient had turned twenty-three before the hypertrophy rapidly increased and treatment was sought. Dr. Wittelshöfer has observed the same phenomena.**

The hypertrophy may be confined to the skin, subcutaneous

* Specimen 3,501, St. Bartholomew's Hospital: Half the great toe of a girl aged ten, which had been hypertrophied at birth, and continued to preserve its abnormal relation to the other toes during the gradual growth of the child.

† 'Pathological Society's Trans.,' vol. xxxiii., p. 235.

‡ *Ibid.*

§ Chance, 'Bodily Deformities,' p. 13.

‖ No. 3,501, St. Bartholomew's Museum: A great toe amputated at the age of ten. It had continued to preserve its abnormal relation in size during the gradual growth of the child.

¶ Eve, 'Pathological Society's Transactions,' vol. xxxiv., p. 299.

** 'Langenbeck's Archiv.,' Band xxiv., Series 57, 1879. 'Ueber angeborenen Reisenwuchs der oberen und unteren Extremitäten.'

and fatty tissues; or the whole of the tissues, including the bones, may be affected. In No. 3,501, St. Bartholomew's Hospital Museum, the only bone which appeared to be hypertrophied was the last phalanx of the affected great toe. In No. 3,502, the hypertrophy, which is confined to the three middle toes, affected not only the soft parts, but the phalanges of the toes, and to a less extent the metacarpal bones as well. In most cases the enlargement of the bones is general, as in the case figured by Busch, and as in the specimen 3,502 in our museum. At times, however, the joint-ends of the bones appear to be especially enlarged,* a condition believed by Busch to depend upon an overgrowth of the epiphysial cartilages.† To this enlargement, no doubt, is sometimes due the displacement and dislocation of the toes already mentioned. In the specimen 3,501, before referred to, the heads of the bones were not enlarged, but the joint-capsules were very loose, so that the toes could be bent back upon the dorsum of the foot. It would appear, therefore, that the displacement does not always depend upon the condition of the joint-ends, but rather, at times, on the condition of the joint-capsules. The muscles, as a rule, are normal. Diffuse masses, in the form of cushions of fibro-fatty tissue under the ball of the toes and over the instep, are frequently present, and may give rise, as in No. 3,502, to so much inconvenience that amputation is necessary. At times the whole of the lower extremity is larger than that of the opposite side, as in Mr. Davies-Colley's‡ case, in which the limb was an inch and a half longer, and an inch and an eighth more in circumference, in the lower part of the leg, and two and three-quarters inches in the upper part of the thigh. In Mr. Eve's case, from a woman aged twenty-four, the soft tissues of the toes were immensely increased, and formed a roundish mass at their extremities of softish consistency. The foot was generally enlarged, but its immense bulk was chiefly due to hypertrophy of the skin and subcutaneous tissue of the sole, the skin of the sole being thrown into prominent firm transverse folds, with deep intervening fissures.

* In Mr. Eve's case the posterior half of the first metatarsal bone was nearly two inches in thickness, and was united to the cuneiform bone. Beneath the head of the same metatarsal bone was a semilunar lump of cancellous bone.

† Busch, 'Langenbeck's Archiv.,' Band vii., p. 174.

‡ 'Pathological Society's Transactions,' vol. xxxiii., p. 235.

Associated with the hypertrophy, other abnormalities may exist in other parts of the body. Thus, the one half of the tongue has been found larger than the other, the face asymmetrical, the hemispheres of the brain unequal, and fibrous and fatty tumours have been met with in various situations.* The hypertrophied tissues appear very prone to ulceration. Illustrations of this will be found in the Hunterian Museum.

As regards the microscopical structure, the hypertrophied skin of the sole in Mr. Eve's case showed a thinning of the rete mucosum, with almost complete obliteration of the papillæ. The increase of thickness of the corium was extreme. It consisted of tortuous bands of dense but indistinctly fibrillar tissue, with rather wide intervening spaces, which were shown by injection to communicate freely with the lymphatic system. The lymphatics did not appear dilated. The bloodvessels of the foot were relatively small. The cancellous tissue of the enlarged bones was soft, and the medulla appeared fatty.

The temperature of the hypertrophied limb appears to be variable. It has been found both higher and lower than normal, but generally normal.

Nothing is known as to the cause of the condition, but the walls of the veins have been found hypertrophied, and have been thought by some to have a causal relation, but there is not sufficient evidence of this.

Beside the hypertrophies here described, the whole of one limb may be found larger than the opposite, the enlargement here being symmetrical, and affecting equally and in the normal proportion all the bones of the limb. This form has been called *symmetrical congenital hypertrophy*, in contradistinction to the form here described, and sometimes called *asymmetrical congenital hypertrophy*.

**Treatment.**—In slight cases it has been recommended that careful bandaging should be tried, seeing that congenital tumours, to which in some respects these hypertrophies seem allied, sometimes disappear under uniform pressure. Attempts have also been made to remove the redundant cushions of fat, but without much success. In the case related by Mr. Eve, an attempt to remove the growth around the great toe was following by

* Eve, *loc. cit.*

sloughing, and amputation became necessary. When one or more toes are alone affected, amputation is undoubtedly the correct treatment; walking in this way will be much improved, and the unsightliness of the foot much diminished. In slight cases of general hypertrophy with increase in the length of the limb, a high boot on the opposite limb should be worn as a palliative.

### Supernumerary Toes, or Polydactylism.

Polydactylism is the term applied to supernumerary digits, a condition which in the foot as in the hand is not so very uncommon. The deformity is often hereditary, and can be traced through several generations.

Perhaps the most remarkable instance of this is that given by Sir William Lawrence in his lectures on the 'Physiology of Man.' The supernumerary digits in this family were traced through four generations. 'They were introduced by a female who had six fingers on each hand and six toes on each foot. From her marriage with a man naturally formed were produced ten children with a supernumerary member on each limb, and an eleventh in which the peculiarity existed in both feet and one hand, the other hand being naturally formed. The latter married a man of the ordinary formation; they had four children, of which three had one or two limbs natural, and the rest with the supernumerary parts, while the fourth had six fingers on each hand and six toes on each foot. The latter married a woman naturally formed, and had issue by her eight children, four with the usual structure, and the same number with supernumerary fingers or toes. Two of them were twins, of which one was naturally formed, the other six-fingered and six-toed.'

The supernumerary toe may merely be attached bud-like by a thin portion of skin to one of the other toes or to the side of the foot, or it may articulate with the head of the metatarsal bone by a joint common to it and the normal toe. In other instances the metatarsal bone bifurcates at its distal end,* so that the supernumerary toe has a separate joint. Or there may be an extra metatarsal bone, in which case there is usually an additional bone in the tarsus with which it articulates. In a

* Chance, 'Bodily Deformities,' p. 12.

case related by Mr. Chance* of bifurcation of the distal end of the first metatarsal bone, the first or great toe projected laterally inwards like the thumb in the posterior extremity of the gorilla or chimpanzee, but differed from the thumb in them, in that it was not opposable to the other toes. The abnormal toe in this case was clearly the outer one, seeing that it possessed three phalanges, whereas the inner and abnormally-arranged toe had only two. The supernumerary toe when attached merely by skin to the side of the normal toe is always or nearly always quite small and rudimentary, but of course contains phalanges. As a rule there is but one additional toe, but there may be more. In two notable cases described by Mr. Athol Johnson† and Mr. Mason‡ in the 'Pathological Society's Transactions,' there were four extra toes on the same foot. On neither foot did any of the toes present the characters of a great toe.

In Mr. Mason's case the nine toes had eight separate metatarsal bones; the first toe was a merely loose appendage, and had neither dorsal nor plantar tendons. The tendons supplying the other toes were carefully dissected. Thus, the extensor hallucis sent slips to the third, fourth, and fifth toes; the extensor longus digitorum slips to the sixth, seventh, eighth, and ninth toes; the extensor brevis gave tendons to the fifth, sixth, seventh, and eighth toes, and a separate tendon to the first phalanx of the second toe. There was a communicating slip between the extensor hallucis and extensor longus digitorum. The flexor longus and flexor brevis digitorum went to the second, third, fifth, sixth, seventh, and eighth toes, the long flexor alone to the fourth and ninth toe.

At times the addition of a toe is accompanied by the absence of one of the bones of the leg, or with a deformity of the foot. In a case related by Mr. Parker, of six toes on each foot, the tibia was absent on both sides; the fibula, which was shorter than normal, was at its lower end in its usual relation with the astragalus; the tarsus appeared normal, but the foot was adducted and in contact with the inner surface of the thigh.§

* Chance, *op. cit.*

† 'Pathological Society's Transactions,' vol. ix., p. 274.

‡ *Ibid.*, vol. xxx., p. 583.

§ *Ibid.*, vol. xxxiii., p. 238. The boy was two years old. There was a remote history on the mother's side of a similar deformity.

In Mr. Mason's case, also, the leg and thigh were deformed. There was no patella, the leg was half the normal length, and could not be extended beyond a right angle at the knee, the lower end of the femur forming a rounded prominence in which no condyloid notch could be felt.

These deformities are not uncommonly associated with similar deformities of the fingers. In the case related by Mr. Parker, above referred to, there were five fingers, but no thumb, on one side; and four fingers and four metacarpal bones, but no thumb, on the other side. On each side the radius was absent, and the ulna much shortened.

In St. Bartholomew's Hospital Museum there is a specimen, in which supernumerary digits on the hands and feet are combined with cleft palate, hare-lip, and a condition of the bones known as fœtal rickets, illustrating how a defect of one part may give rise to excess of growth at another part.

**Treatment.**—When the supernumerary toe is merely attached by a fold of skin to the side of one of the other toes or to the side of the foot, amputation is a sufficiently trivial operation, and should be done in infancy. When six distinct toes are present, unless a source of annoyance or discomfort to the patient, which they seldom are, they had better be left alone. But if walking is seriously interfered with, or the extra toe gives pain by being chafed by the boot, or the additional width of the foot necessitates a wide and ugly boot, one toe may be amputated. Removal is usually more called for when there is a supernumerary digit on one foot only, and boots of unequal size have to be worn, than when both feet are affected. When the supernumerary toe articulates with the metatarsal bone by a joint common to it and the normal toe, it is generally advised that the amputation should be performed through the shaft of the phalanx, leaving the articular surface intact, since, if the whole phalanx is removed, the joint common to the supernumerary and the normal toe would be opened, and might inflame and subsequently become stiff and ankylosed. The portion of phalanx left is said not to grow* with the development of the child, but to remain buried in the soft tissues, and cause no inconvenience.

* Sedillot, 'Notes sur l'amputation des doigts supernumeraires:' 'Comptes Rendues de la Société de Biologie,' Series i., tome v., 1853, p. 145.

With modern surgical precautions, however, there need be little fear of inflammation or ankylosis, even though the joint be opened.

### Union of the Toes, or Syndactylism.

A webbing of the toes, or a fusion of the toes more or less complete, is of occasional occurrence. The webbing may affect only two toes, or all the toes may be united in this way. The web, as in the fingers, may be confined to the proximal portion of the affected toes, or it may be complete. At times it is found uniting the distal portion of the toes, a cleft existing between the proximal portions. We have not met with this condition. The web may consist merely of skin and some cellular tissue, and be quite thin and delicate; or it may be thick and leathery, almost amounting, in some instances, to a fusion of the toes. In such cases the tendinous structures may be involved. When the fusion of the toes is complete, two toes, as a rule, are involved; but all may be fused into a mass, the nails alone indicating the situation of the several digits. When two toes are fused, the corresponding metatarsal bones are generally likewise more or less completely fused; but there may be some indication of two metatarsal bones, in that the bone is broader than the others, or presents some slight longitudinal groove or an attempt at bifurcation at the proximal end. In extreme cases the tarsus and metatarsus, with the phalanges, have been found fused into a single mass of cartilage or bone. As regards the phalanges, when two toes are fused, either the proximal or the distal phalanges have been found fused, or the fusion has been complete.

Webbing or fusion of the toes is at times associated with a similar condition of the fingers, or with some other deformity, as absence of the fibula, talipes, spina bifida, etc. The condition is often hereditary, or some other developmental defect may be found in one or other of the parents.

**Treatment.**—In the cases that have come under our notice, the deformity, whether a mere webbing or a more or less complete fusion, has given rise to no inconvenience, and no treatment has appeared either desirable or called for. Some of the opera-

tions suggested for webbed fingers would no doubt be equally applicable to the toes; but since the toes are covered, and are not used for prehensile purposes, neither on account of appearance nor utility can any operation be advised. Where, however, one of the fused toes, owing to concomitant malposition, is a source of annoyance and pain to the patient, it may be amputated.

# INDEX.

THE END.

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